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A

SHORT ACCOUNT

OF THE

MODES OF SEWAGE DISPOSAL

IN SOME OF THE

CHIEF TOWNS OF ENGLAND.

TOGETHER WITH A LITTLE

INFORMATION ON THE SUBJECT LIKELY TO BE OF USE IN INDIA.

BY

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LONDON:
PRINTED BY GEORGE E. EYRE AND WILLIAM SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.
FOR HER MAJESTY'S STATIONERY OFFICE.

1869.

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MISCELLANEOUS.

LIST OF PAMPHLETS, &c., CONSULTED.

"What shall we do with our Refuse?" Manchester sewage, (Henry Simpson,) is the title of a pamphlet of which the drift seems to be to point out that if the sifted ashes from the grates are used in a proper manner, it will supply the place of earth to Moule's system, and remove part of the great objection to it, *i.e.*, the great expense of carriage.

"The high Death Rate, in answer to the above" (Manchester.) (J. C. Morrell.) Points out the mode in which the ashes may be sifted by a grating, and gives a drawing of the kind of privy for effecting this with least trouble.

"Remarks on Town Sewage." Arthur Jacob. Represents the advantage of the irrigation system as financially sounder than any other. Instances Croydon, and disparages the earth system on account of the expense of the earth carriage.

"Sewage," and its Application to Crops. Thomas Carghill, C.E. Gives plans of the mode of conducting the sewage over the land, and several interesting details of the effect of sewage.

"Sanitary Siftings," by a Naval Officer. An advocate of Moule's earth system.

"On the Disposal of Sewage in Towns." Henry Waugh, C.E. Pointing out the failure of the lime process at Leicester, and the success of the lunatic asylum irrigation works.

"The A. B. C. Process." Report of the Experiments at Leicester.

"Collection and Removal of the Refuse of Edinburgh," by C. Macpherson, Esq., C.E., burgh engineer. A very exhaustive description of the irrigation and other works at Edinburgh, where 336 acres are cultivated, and showing the method of applying the sewage.

"Sewage of Towns," Leamington Congress Papers. Conference on several systems.

"What are the best Means for Disposal of the Sewage of Towns?" J. Walworth, Manchester. Advocate of the ashpit system.

"The Drainage of Paris and London." Hederstadt and Bazalgette. Discharge by outfall into the river at one locality.

"Local Management Act," Weale. Obligations of local authorities and house owners in respect of drains, &c.

Stockhardt's Principles of Chemistry. Bohn's Scientific Library.

"Water, and its Impurities and Purification." London and General Water Purifying Company. Tests for impurities.

A Chemist's View of the Sewage Question, Ed. C. C. Stanford, F.G.S. (See "Chemical News," No. 495, vol. 19.) Suggests the use of sea-weed charcoal for earth in Moule's system.

Usury, by W. C. Sillar; pointing out the evils of the system which tend to keep the industry of a country in a state of stagnation and prostration, by which the health of the community must suffer.

Treatment of Sewage, by John Hart, Esq. (Leamington); giving a plan of a circular purifier for sewage, prior to its use in irrigation.

British Guano, by Dr. Taylor, Romsey.

INTRODUCTION.

Extracts from the "Staudard," July 12, 1869.—"Two important judgments have just been pronounced in the Chancery Courts having reference to the disposal of town sewage. One case affects the Local Board of Health at Merthyr Tydvil, and the other the Corporation of Halifax. In each case we find that the authorities have been zealously engaged in carrying out works for draining their town, the success of these efforts being indicated by the magnitude of the nuisance inflicted elsewhere. Merthyr Tydvil poisoned the Taff, to the annoyance of the parties owning and working certain exteusive collieries. Halifax appears as the principal offender in converting a sparkling brook, called the Hebble, into a common sewer, to the detriment of a firm of damask and worsted manufacturers, with their tenants and workpeople. As long ago as last September an injunction was granted against the local board at Merthyr Tydvil, but the authorities had continued the flow of the sewage as before. The Master of the Rolls has now issued an order of sequestration, which is to be held in abeyance until a period in Michaelmas Term. The defence set up by the authorities was that they were acquiring land for irrigation and could do nothing until they got it. At Halifax the nuisance was partly denied and partly excused, on the ground that the plaintiffs had for a long time acquiesced in it, and as members of the Town Council had actually helped to bring about the state of things to which they now objected. Vice-Chancellor Sir W. M. James, in giving judgment, expressed his conviction that so large a sewer could not discharge into so small a stream without creating a nuisance, in addition to which he was satisfied by the evidence that a nuisance of a most offensive character did actually exist. He therefore 'had no hesitation' in granting an immediate injunction to restrain the Town Council of Halifax from extending their system of drainage, and an injunction to take effect in June 1870, against pouring out sewage from the present outfalls in an uupurified state. How the authorities of Halifax are going to proceed is not clear; but the Vice-Chancellor at the close of his judgment said he was satisfied the corporation would in time be able to remedy the evil, so as to prevent it from being practically a nuisance, and to deprive the plaintiffs of any ground of complaint."

In the course of a few inquiries into the best mode of dealing with the sewage and refuse of towns, I found that hardly two persons were of the same opinion. Those that had had any experience of any one system were generally opposed entirely to every other.

In seeking information from the pamphlets of various persons who had taken an interest in the subject, to the extent of incurring the expense of printing, I found that these contained a great many arguments for and against, without going into any particular description of the *modes* adopted for carrying them out. They apparently assumed that we knew all about the details, and that they were only called upon to deal with it in a large and comprehensive way. It has been my object in the present paper to give a description of a few of the methods I have seen adopted in England, and I have supplemented the information by such

extracts from the pamphlets as it might be considered should not be wanting to make the thing as complete as practicable. I must, however, explain that it has not been my object to instruct engineers or scientific persons in any one of the points noted by me, but to place such an amount of information as can conveniently be got into a condensed shape at the disposal of all interested, that they may be able to judge for themselves from what *has* been done what could be attempted again. I cannot hope that the paper will be satisfactory in all respects, for the ways and means of collecting information are sometimes rather difficult. I may mention that in all cases where I have applied to the local authorities of any town I have invariably received the greatest courtesy and the fullest information on subjects connected with the drainage or water supply, and should any of them read this paper I trust that if I have misrepresented any of the facts they will rest assured that it has occurred unintentionally. The notes have been made without any particular reference to opinions, and I have endeavoured to confine myself entirely to descriptions of works I have either visited or read of.

The great question that occupies the minds of all concerned in the disposal of sewage, is how to prevent the pollution of rivers or sea coasts.

At one time it was considered that waterclosets with a perfect system of sewers and drains discharging into the sea or river was the remedy for sickness in towns.

It has proved, however, that the discharge of sewage into the rivers and the sea has led to the defilement to an alarming extent of the shores, and that something yet remains to be done before we are to be free from danger.

Some are for disposing of this sewage by irrigation, others are for dedoorizing and precipitating the solid part and allowing the liquid to flow into the river. Others advocate the system of ash pits, while there are some who go to the root of the affair and wish to prevent the solid excreta from entering the sewers at all.

Then it is becoming generally understood that, apart from the question of the most effectual remedy for preventing sickness from foul rivers and streets, by our present system we are depriving the soil of those fertilising agents contained in the sewage which are necessary for the reproduction of the same substances from which the food has been derived; and it has been the aim of all the advocates of any one system of drainage disposal to combine either profit, or the greatest economy by rendering the sewage as valuable as possible.

Now it appears to me that the only way to consider the questions of relative merits of any of these systems is to concede-

that the one point to be gained is cleanliness of towns and purity of the streams and shores, and *that* one may be preferred which is most convenient. Should any profit be gained by any system of deodorization or irrigation in connexion therewith which may be necessary to effect the end in view, so much the better.

Of all the systems I have seen I cannot point out one that may not be useful under certain circumstances. It seems absurd to say that any one system is perfect, or that it can be applied to all towns.

I am inclined to doubt that any great *profit* (in money) to the public in general has been realized as yet with the proceeds of sewage, from whatever system, but that advantage of some sort or other has been derived in almost every case, in the way of prevention of nuisances, can hardly bè denied.

It may be useful to note a few of the objections that have been raised to some of the systems against some of the advantages.

Discharge from Waterclosets into Rivers.

Against.	*For.*
Waterclosets have been objected to altogether by some people, the chief cause being the foul sewer gas that finds its way up from the sewers.	Extreme luxury of the apparatus.
	Obviated by proper traps.
	Some system of sewers for liquids is essential.
Percolation into wells from defectively constructed sewers.	Good work should be put into the sewers.
Waste of the sewage as a fertilizer of the soil.	Not profitable to utilise.
Pollution of rivers and sea coasts.	Removal of the soil by water by gravitation is the cheapest.

Irrigation.

Against.	*For.*
Purifies the water partially only, leaving the soluble impurities as before.	Purifies the water completely for drinking even. Cattle will prefer it to hard water. Fish live in it.
The emanations from the irrigated ground are pernicious to health.	Not proved. Judgment required in selecting the ground.
The only crop raised, rye grass.	Enormous crops of grass are raised, not only rye grass but meadow.
Hay cannot be made.	It has been and is made successfully at Worthing and Aldershott.

Financially a failure to apply all the sewage of a town on *one* farm.	Experience begins to show that the sewage could be more profitably expended on much larger areas, and that other than rye and meadow grass crops will tako sewage with advantage if not overdone. There is everything yet to learn in irrigation farming in England.
The crops all run to straw.	So they would with too much irrigation, even with pure water or a heavy rainy season.
The expense of a wide distribution of sewage over land is too great	
The land cannot take up all the sewage during a heavy flood, when there is most need to get rid of it.	It is then so dilute as to be harmless, and may be turned into the river.
During harvests where is the sewage to go to ?	To rye grass fields, of which it will be necessary always to have a reserve.

Deodorizing and Precipitation.

Against.	*For.*
The value of the manure is not remunerative.	It is different in different systems.
The lime process passes off water clearer than before, but not agreeable in colour or taste. It kills the fish.	The lime process probably gives the least valuable. At Leicester it realizes 1*s*. per ton.
The Stroud system produces a manure only after treatment with other chemicals, and is not remunerative.	The water is clearer than that from the lime process. Manure fetches 7*l*. 10*s*. per ton.
The A. B. C. system.	Probably gives the water off clearer than either. Manure sells at 3*l*. 10*s*.
The results in the purification of rivers are not always satisfactory.	The systems are not always carried out with perfection, but hardly a case can be cited where substantial benefit has not been derived in respect of the retention of the solid matters, if proper arrangements have been made.
Simple settlement tanks do not purify the water.	No, but they do arrest a great part of the heavy matter.
Deodorizing alone is no remedy for the pollution of a stream.	It is better to combine the operation with settling tanks.
Filtration is of no use. Filters require so frequent changing and cleansing.	In most cases filters of some sort are used in connexion with tanks. Those at Stroud do not require changing at all frequently ; at Ealing they answer.
Deodorizing generally destroys the value of the residuum as a manure.	

The Ash Pit and Cesspool.

Against.	*For.*
Are the source of every ill that occurs in the town, filling the air with putrid gases and polluting the wells with their leakage.	Ashes and charcoal thrown into the cess pits, combined with frequent removal; an economical remedy, as at Manchester. By this course the expense of carriage of much rubbish by scavengers is made less expensive, as mixed with nightsoil it can be sold and carted away at the expense of the farmers.
The mortality in towns where these exist is high.	Explained by other causes.

Dry System.

Against.	*For.*
They do not do away with the necessity for house drains or sewers for liquid refuse.	These are the only ones that combine least nuisance with most manurial value of the residue.
The size of the sewers is not thereby affected materially.	They entirely exclude nightsoil from the drain.
Moule's system.	
The objection to this is the enormous carriage of dry earth required and the impossibility of procuring it in many cases at all.	Retains the whole of the fertilizing properties of the fæces and urine. The manure fetches a minimum price of 3*l.* per ton.
Taylor's system.	
This system provides that the urine runs away in the house drains. The urine contains salts which make it six times as valuable as the fæces.	Completely meets all objections. It produces a manure valued at 8*l.* per ton. There is no earth carriage.

It appears to be impossible to get rid of sewage by simply allowing it to flow into a river or the sea.

Wherever the water approaches stagnation or least velocity the sediment is sure to be thrown down, and as such places exist in all localities a nuisance is inevitable. It was hoped that by prolonging the outfall sewer for the London drainage down the river to Barking the nuisance would be removed; but though it has benefited London the inhabitants of Barking are petitioning to have the nuisance removed from their neighbourhood. From the *Standard* of 3d July 1869, a report of an inquiry by Mr. Rawlinson, C.E., the Government inspector, shows that some 700,000 cubic yards of mud are estimated to have been deposited in about three years in the bight in which Barking Creek is situated since the Northern outfall works have been completed.

To remove this at 1s. 9*d.* per cubic yard would cost 61,250*l.*, or 20,000*l.* annually.

This is the produce of sewage of 50 square miles of the northern districts, with a population of 2,300,000, the average flow for 24 hours from which being 33 million gallons.

The Thames being a tidal river has advantages over others probably, but at Liverpool, which has a similar advantage, they have adopted a system of irrigation just lately. At Southampton they have been in treaty with the A. B. C. Deodorizing Company, though they had the advantage of a tidal reach (the Southampton Water) to discharge into. At Worthing, which can discharge by gravitation direct into the sea, they have pumped sewage to irrigate instead.

Towns situated on rivers that are inconvenienced by the sewage discharge of towns higher up the river are empowered to issue an injunction to restrain them from damaging the river by discharge of such sewage before purification, and in almost all towns something is being done to effect an improvement.

It is true that many yet discharge their sewage into rivers or the sea; but when the result of the various trials of different systems has shown which is the most profitable, it is unlikely that such will continue to be the case, and that towns will adopt one or other method of purification is certain.

As it may not be generally understood in what way the question of the sewage disposal is considered to be of such vital importance to the health of the country by those skilled in the science of hygiene, I have made a few extracts from papers bearing on the subject, a list of which is given.

I have thought it might be useful also to make some extracts of the local Acts in force for the guidance of those unacquainted with the rules at present obtaining.

SEWAGE DISPOSAL.

CHAPTER I.

The Evil of Sewage misapplied, and its proper Uses.

*A constant motion is taking place in the living animal as well as in the living plant.

In a chemical point of view animal life is distinguished from vegetable life by the uninterrupted reception of oxygen, and separation of carbonic acid and water.

During the life of plants, on the contrary, carbonic acid and water are received, and oxygen separated.

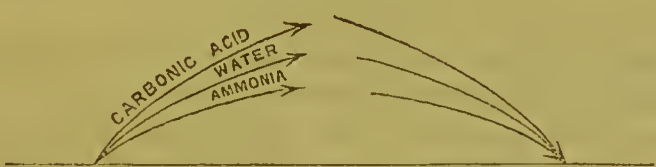
The plant consumes	Carbonic acid.
„ animal „	Vegetable tissue, sugar, gum, fat, &c.
The plant consumes	Ammonia.
„ animal „	Albuminous substances, gelatine, &c.

During the process of decay and putrefaction the dead animals and plants are converted into carbonic acid, water, and ammonia; and from these three products of decay are reproduced all the innumerable plants which cover the surface of the earth.

On the putrefaction of albuminous substances their nitrogen and sulphur (and phosphorus) combine with hydrogen, forming ammonia and sulphuretted hydrogen (and phosphoretted hydrogen).

Ammonia is formed by nitrogen and hydrogen, by their union at the moment of liberation from a decaying albuminous body, in proportion one to three.

It is thus seen how the elements of nutrition are in a constant circulation from the dead to the living.



Dead Animals and Plants. Living Plants.

The plants are the food of man and animals, and the nitrogen obtained from the ammonia they have consumed is again put into circulation.

The *solid excrements* of men and animals consist for the most part of those constituents of this food which are *not dissolved* in the stomach. The beneficial influence of solid excrements on vegetation is principally owing to the inorganic compounds contained in them (lime, magnesia, phosphoric acid, and silicic acid).

* Stockhardt's Experimental Chemistry.

The *urine* contains the *soluble salts* originally in the food, also the nitrogen no longer necessary for vital processes.

The amount of inorganic substances in the animal excrement or manure may be accurately ascertained from the food itself which is consumed. The food has only to be burnt. Those parts of it which are insoluble correspond to the substances in the fæces, those which are soluble to those in the urine.

Nitrogen is contained in urine either in the form of urea, uric acid, or hippuric acid.

If excrement, rich in uric acid, is allowed to remain exposed to the air, it will absorb oxygen and afterwards contain oxalate of ammonia; if the latter takes up more oxygen it passes over into carbonate of ammonia. Thus is explained why we frequently find in some sorts of guano only traces of uric acid, but instead of it large quantities of oxalates.

Guano (birds' dung) owes its efficacy to the uric acid contained in it, or if this has already undergone decomposition, to the ammoniacal salts formed, and in part also to the inorganic salts, sulphate, phosphate, and muriate of potassa, soda, lime, magnesia, &c., present.

It is obvious that carbonate of ammonia is to be regarded as the principal product of decomposition of urine. To prevent the evaporation of the volatile carbonate of ammonia gypsum or dilute sulphuric acid may be added, by which means sulphate of ammonia is formed.

* Organic Matter

cast off from animal organisms is subject to very rapid chemical changes, attracting oxygen from the air, and becoming transformed in various gases, especially—

1. Sulphuretted hydrogen.
2. Sulphide of ammonium.
3. Carbonic acid.
4. and often phosphuretted hydrogen.

All of these are inimical to animal life.

The aptitude to turn into gas is increased by admixture with water, especially when exposed to the air.

In this way running streams get rid of their organic matter by oxidation at a short distance from the point of contact with the rivers.

Dr. Barker's experiment showed that—

1. Sulphuretted hydrogen produced vomiting and purging, and that the mode of dying was by asphyxia (suspension of motion of heart), and that as small an amount as ·051 per cent. produced specific symptoms.
2. Sulphide of ammonium causes vomiting but no purging, though occasionally tenesmus. When the dose is large death occurs with laboured respiration. There is op-

* Thomas Hawksley, Esq., M.D. Leamington Congress Papers.

pression of the nervous system, passing into complete coma, and the condition is that of typhus fever.

3. Carbonic acid affects first the respiration ; 1 or 2 per cent. if inhaled will interfere seriously with the oxidation of the blood.

As these gases are so objectionable, it becomes necessary to use some chemical means to render them harmless if possible by combination with some other substances.

It should be remembered that—

Phosphorus is insoluble in water.

Ammonia always otherwise in water, it cannot be solidified.

The means adopted to solidify the gas ammonia is by treating with sulphuric acid, by which the ammonia becomes a sulphate.

Any mixture of lime with ammonia (as generally found as a carbonate) tends to abstract the carbonic acid and liberate the ammonia, which soon makes itself evident by the odour.

Perchloride of iron is referred to in the experiments at Leamington, as used to precipitate the sulphuretted hydrogen.

Magnesia is referred to also as being used to precipitate phosphorus and ammonia as phosphates.

The gases from a drain will be absorbed to a great extent, if not entirely, by charcoal.

Dry earth will absorb animal refuse and prevent any smell arising, &c.

Now, when the food swallowed and digested has parted with its nourishment, and the refuse is cast out as no longer required, it will be evident that such matter will not be fitted for again taking into the system till it shall have gone through the regular circle of decomposition and absorption by plants ; and Dr. Richardson has shown that when any such sewage matter is again taken into the system it is liable to cause all those most fatal diseases man is afflicted with, known as cholera, &c.

Organic Poisons.

Lecture by Dr. B. W. Richardson, 25th October 1866, to the Leamington Congress, on the poison of spreading diseases : their nature and mode of distribution.

After introducing the subject by a few remarks on the law of life and death and the causes of diseases external, &c., Dr. Richardson proceeds to show that 15 of the worst diseases man is subject to, such as cholera, smallpox, typhus, yellow and other fevers, diphtheria, ophthalmia, &c., are traceable mainly to the poisons which may pass from sewage.

1. Each disease proceeds from a specific poison, which is an organic one.
2. The organic poisons are perfectly inodorous, and no communicable diseases depend upon gases of decomposition (carb. acid, sulph. hyd., ammonia, phosph. hyd., or carb. hyd.). These gases are very perceptible to the nose, but

they will not produce any of the above diseases. Air containing these, however, is very deleterious to health, and even such a small proportion of sulphuretted hydrogen as $\frac{1}{5}$ to 1,000 will kill, and the same with phosphuretted hydrogen.

3. The distinction between gases and organic poison is that directly we remove the subject from the gas the symptoms will cease, while a person having become once affected with organic poison the symptoms will go on developing.
4. The poisons will all dry solid. If solved it has been found that dilution to a certain extent will not produce any milder effects than the original bulk, but beyond that certain point there was no disease at all produced. This accounts for the admixture of the water of rivers destroying the effect of these poisons.
5. The poisons are carried by the vapour of the body mechanically, as long as there is heat; directly the body is dead these poisons become no longer infectious.
6. Poisons are harmless in their dry state.
   Exposed to the sunlight they lose their activity.
   Snake poison is destroyed by sunlight.
   Stagnant pools become inert in the sunlight.
7. *The Origin of Poisons.*—They all proceed from albumen. The action of them is this, that each particle of any one poison brought in contact either with the blood or certain secretions has the power of turning the albuminous part of the same blood into a structure like itself.
8. The mode in which poisons may be transmitted is in three ways:—
   (i.) In sewage as dry solid matter (dust) which will be swallowed.
   (ii.) By the linen of diseased persons.
   (iii.) In water, or in water suspended in the form of vapour.
9. The mode of communication of poisons is different in different diseases; for—
   (i.) Measles, scarlet fever, typhus, it is always inhaled.
   (ii.) Diphtheria, glanders, ophthalmia, require direct contact.
   (iii.) Smallpox may be inhaled or inoculated.
   (iv.) Cholera, yellow fever, &c., ague, swallowed poisons, may be called specifically sewage poisons.
10. Disposal and destruction of organic poisons:—
   (i.) Ventilation and a high temperature are the best things to prevent infection; also sunlight.
   (ii.) Certain agents oxidize or destroy them, *i.e.*, iodine, which vaporizes at 70°, and a drachm will be diffused in 24 hours, if exposed in a bottle covered at mouth with a little muslin.
   After iodine comes chlorine; not more than two drachms should be diffused in a room 10 ft. × 10 ft. × 10 ft.; in course

of an hour the chlorine will be diffused. It should be placed in a 2 oz. bottle and allowed to diffuse.

11. When the poisons are in the fluid state, as when passing from the bowels of cholera patients, a large series of experiments points to the iodine as almost specific, which really acts as an oxydizer.
12. When the poisons are in the form of dry substances spread upon clothes, very important rules require to be observed.

    Cholera has been known to be very fatal to laundresses who have the washing of patients' beddings, &c.

    In cold water under 50° clothes remain quite harmless. To destroy the poison they may be thrown at once into boiling water in a cauldron, with a good shaft to the chimney to carry off the vapour ; the draught should be closed so that no one may be exposed to it.
13. Viewing the health side of the question entirely, the doctor thought that there could be no doubt but that the town that would be most happy in regard to its health would be that one wherein a water supply was derived from one source, and a drainage well flushed, but not over large, and a conduit to take as it was produced every particle of sewage clean away into the sea.

Seeing how important it is that the cast-off matter should be carefully prevented from entering the system again by the most effectual measures of sewage disposal, we will now proceed to ascertain what has been done at some of the towns who have shown themselves foremost in their endeavours to approach a solution of this difficulty.

CHAPTER II.

Descriptive Account of existing Sewage Works.

Main Drainage of London.*

London main drainage provides for the disposal of the sewage by discharge into the river Thames at such a distance below the city that it may not be brought back again by the flood tide.

The districts north and south of the river are drained by entirely separate systems.

On the north side the principal features of the system are three great sewers, called the high, middle, and low level respectively, placed in the basin of the Thames so that the low level sewer alone requires the aid of pumps to discharge its sewage.

On the south side of the river there are two large sewers, the high and low level, the latter requiring pumps.

The inquiries made in determining the description of work required were as follows:—

(1st.) At what point of the river and state of the tide can the sewage be discharged so as not to return within the more densely inhabited parts of the city?

(i.) It was found by experiments with floats that the same water remained with the floats within a dozen miles of the same spot for days.

(ii.) Also the delivery of sewage at high water into the river at any point is equivalent to its discharge at low water at a point 12 miles lower down the river; therefore 12 miles of sewer is saved by discharging sewage at high instead of low water.

(2nd.) What is the minimum fall which should be given the sewers (intercepting)?

(i.) One and a half miles per hour mean velocity is shown to be required when running half full.

(N.B.) Six inches velocity will lift fine sand; 8 inches sand as coarse as linseed; 12 inches will sweep along fine gravel; 24 inches pebbles an inch in diameter.

(3rd.) What is the quantity of sewage to be intercepted, and does it pass off in a uniform flow at all hours of day and night, or how?

(i.) Twenty-five gallons of water per head was the average at one time, but an improved supply of 5 cubic

* Paper by Mr. Bazalgette.

feet or $31\frac{1}{4}$ gallons was contemplated. 30,000 people per square mile was calculated for average densely inhabited districts, 20,000 in outlying districts.

(ii.) Experience has shown that sewage is not discharged at a uniform rate during 24 hours. Provision has been made for discharging *half* the sewage in six hours of the day.

(4th.) Is the rainfall to be mixed with sewage? Is it to be carried off by the intercepting sewers, or how?

(i.) A double system of sewers has been found impracticable; the expense alone would be 10 or 12 millions.

(ii.) The rainfall is admitted into the sewers, and overflows are provided for exceptional storms at the valleys. With a fall of rain equal to $\frac{1}{4}$ inch in the sewers in 24 hours it is calculated that there would be 12 days in the year when these overflows would come into play for the six hours of greatest sewage flow, but as the sewage would be greatly diluted nothing offensive would result.

(5th.) Having regard to all these results, how are the sizes of intercepting and main drains to be determined?

By the formulæ of Prony, Etelwein, Du Buat.

(6th.) What kinds of pumping engines and of pumps are best suited for lifting the sewage?

(i.) The engines are condensing double acting rotative beam engines, and the pumps are plunger or ram pumps, the sewage being discharged through a series of hanging valves.

The contractors of the engines at Crossness and Abbey Mills guarantee that the engines shall when working raise 80,000,000 gallons 1 foot high with 1 cwt. of Welsh coal.

Form of the Sewers.

For intercepting sewers, circular.
Minor branches, egg-shape.

DESCRIPTION OF THE MAIN SEWER.

——	Length.	Area drained.	Size.
NORTH SIDE.			
High level - -	7 miles	10 sq. miles	4 ft. diam. to $9\frac{1}{2}' \times 12$ ft.
Middle level - -	$11\frac{1}{2}$ „	$17\frac{1}{2}$ „	$4\frac{1}{2}' \times 3'$ to $10\frac{1}{2}'$ diam.
Low level - -	$12\frac{1}{4}$ „	11 „	$6\frac{3}{4}'$ diam. to $10\frac{1}{4}'$ diam.
SOUTH SIDE.			
High level - -	$16\frac{1}{2}$ „	20 „	$4\frac{1}{2}' \times 3'$ to $10\frac{1}{2}' \times 10\frac{1}{2}'$
Low level - -	10 „	20 „	4 ft. to 2 culverts $7' \times 7'$

Pumping Stations.

	Sewage flow per minute.	Height raised.
North Side.		
Abbey Mills - - -	15,000 c. ft.	36 ft.
Chelsea - - - -	„	17½ ft.
South Side.		
Deptford - - -	10,000 c. ft.	18 ft.
Crossness* (outfall) - -	20,000 c. ft.	10 to 30 ft.

The sole of the north outfall is 1½ ft. below high-water mark.

The sole of the south outfall is 9 ft. above low water.

The fall in the outlets is reduced to a minimum of 2 feet per mile.

The total cost of the main drainage when completed will have been about 4,100,000*l.*

The sums for defraying the cost have been raised by loan, and are to be paid off by a rate of 3*d.* in the pound levied on the metropolis, which produces 180,262*l.* per annum. The principal and interest will be paid off in 40 years.

The average consumption of coals will be 20,000 tons per annum.

The sewage at present amounts to—

On the north side, 10,000,000 cubic feet per diem.
On the south side, 4,000,000 „

This is expected to increase to 11,500,000 and 5,750,000.

This, too, in addition to rainfall—

North side, 28,500,000 cubic feet.
South side, 17,250,000 „

Or a total of 63,000,000 cubic feet per diem.

The whole system is now complete, with the exception of some smaller parts of the low level.

As the sewage is only discharged at high water into the river from the outfalls, covered reservoirs have been constructed at the outfalls in which the sewage is stored till the time of high tide (about 11 hours per tide).

The Barking reservoir is 16¾ feet deep and covers 9½ acres.

At Crossness the reservoir covers six acres of ground.

The Deptford pumping station lifts the maximum amount of 10,000 cubic feet of sewage 18 feet high by four expansive, condensing, rotative beam engines each of 125 H.P.

The Crossness pumps are four in number, 125 H.P. each.

* The sewage is discharged at high tide only, being held in a reservoir at other times, but the sewer is at such a level that it can discharge its full volume by gravitation about low water.

There is a similar reservoir on the north side near Barking.

Abbey Mills Pumping Station.

This station is for the purpose of raising the sewage of the low level sewer, which originally discharged into the Thames at this place, in order to pass it down the main recently constructed to discharge it down the river some five miles off (at Barking).

The sewage is raised 19 ft. in vacuo.
17 ft. force.

Total - 36 ft.

The amount to be raised, including rainfall, 15,000 cubic feet per minute.

Number of engines, each separate, 8.

The position of the cylinder and beam are indicated *a*, *a*, &c.

Size of the pumps, 3 ft. $10\frac{1}{2}$ in. diameter, 4 ft. 6 in. stroke, double acting.

Two pumps on each beam.

N.B.—The amount of sewage at each stroke or revolution of the flywheel will be four times the quantity calculated from the above size.

The number of strokes per minute, 9.

Horse power of the engines, each 142.

Fall in the main sewers per mile, 2 feet.

Tanks to receive the sewage under the whole area of the building 14 feet deep.

Diagram of Plan of the Engine House.

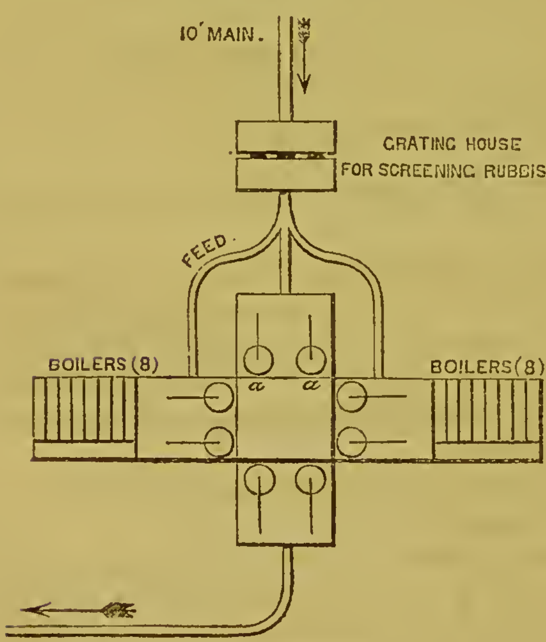
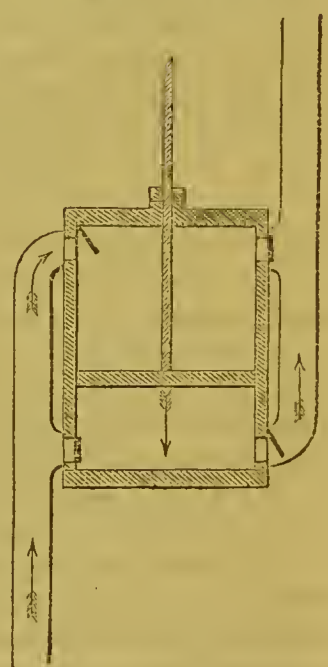


Diagram of the Double-acting Pump.



The sewage of Chelsea is pumped into the end of the low-level sewer at Cremorne, and so is pumped twice.

The building has been completed about two years, and is a most elegant one, reminding one more of some eastern palace than an erection connected with anything so *in*elegant as drainage.

Gauges indicate the depth of sewage in the tanks, and as many engines as are required are set to work to pump it up. Provision is made to enable the men to prevent overflow of tanks by a culvert opening into the river.

When I visited the works two pumps were at work, with 9 feet of sewage in the tank.

I was informed that a tumbler full allowed to stand would not produce more than a quarter of an inch of sediment.

The proceeds of screening of the heavy matters which would be liable to damage the pumps are treated with some ashes or deodorant, and sold to farmers, but there was no very great quantity.

It is only intended to give an outline of the principal features of the London main drainage for comparison with other towns mentioned in this report.

It is impossible to mention half the interesting details connected with the subject; they are fully set forth in the "Main Drainage of London," by J. W. Bazalgette, Esq., edited by J. Forrest, Esq., Secretary of the Institution of Civil Engineers.

IRRIGATION.

Croydon. Population 20,000.

The system of utilization by irrigation has been adopted here with great success.

The town is very efficiently sewered, and experiments in the way of deodorization were tried but found not to answer. There are at present two farms under irrigation, Croydon being so situated that all the sewage could not so conveniently be brought to the same farm, if at all. The Beddington farm, of some 300 acres, is situated on a soil having gravel as a subsoil. The Norwood farm, 60 acres, is on clay soil.

It is found that the latter is not available for meadow grass to the extent the former is.

The gravel soil has afforded, and continues to do so, some excellent pasture for cows and oxen in the shape of meadow grass, and also rye grass for cutting as forage for horses, &c., in the town, and the town receives rent at the rate of 5*l.* an acre from the lessee, land being rented in the neighbourhood, as I was informed, at the rate of 25*s.* to 30*s.* per acre.

The cattle seemed to look very well on the grass, and the forage that was being cut looked excellent.

The smell was not in the least offensive from the land when I was there, though I could perceive an earthy smell, such as is met with in a newly ploughed field; the ground appeared to be damp and saturated, and there is no doubt that a *larger area* of ground would be better for the sewage to be distributed over, and it was stated that the land should be broken up and allowed to stand over for a season, being planted with other crops at the same time without any sewage applied.

There was a field of wheat which was the second on the same

ground in succession, two crops of turnips having been taken previously. Seven quarters to the acre was the crop of wheat stated to have been produced last year. That now on the ground looks somewhat sickly.

No other crops have been tried.

The rule appears to be to plant seed for rye grass every three years, to reap the grass five or six times a year, and irrigate it whenever it will bear the sewage. Also to irrigate fields of permanent grass (meadow) for feeding cattle on the ground, and allow them to grow for 10 or 15 days, then turn the cattle on to them. This latter grass never seems to want re-sowing. It would not cut for forage.

The sewage falls by gravitation to the land in both farms. In the former (Beddington) the sewer is some 3 ft. in diameter, and delivers sewage of the usual dark colour, full of flocculent matter, which is distributed over the land by main channels, which are laid out in a very simple manner at right angles to the greatest slope of the field.

I saw sewage thick and full of suspended matter passed over a length of 25 or 30 yards of ground, and delivered apparently quite clear of all suspended matter.

That it could not have been free from matter in solution, Mr. Barry of Leamington shows by quoting an experiment at Edinburgh, being an analysis of sewage water after it had passed over five fields in succession. The analysis gave in the sewage at the drain head—

	In suspension.	In solution.
	224	87
After 1st field - -	52	87
" 2nd " - -	31	89
" 3rd " - -	15	82
" 4th " - -	2½	67
" 5th " - -	2	72

I tasted this water and found it very agreeable, and it flowed off in very nearly the same volume as it was delivered as sewage, looking excellent. It seemed a pity that this water could not have been further utilized instead of being passed off into the river Wandle.

An interesting fact was told me regarding the fish, of which I saw several in the purified sewage, viz., that previous to this system of purification, damages were claimed for the wholesale destruction of the fish in the river. After this purification the complaint had assumed an entirely different character, viz., that the fish had deserted the river for the channel outfall of the purified sewage!

The banks of the outfall were not in the least polluted with flocculent or other matter, and in that respect differed completely from the feed channels conveying the sewage to the fields, which were decidedly black.

The mode of applying the sewage is the same throughout the whole of the two farms.

Sewage enters at S is dammed back by a board at A, flows to *a*, where it is stopped by another board which makes it flow down

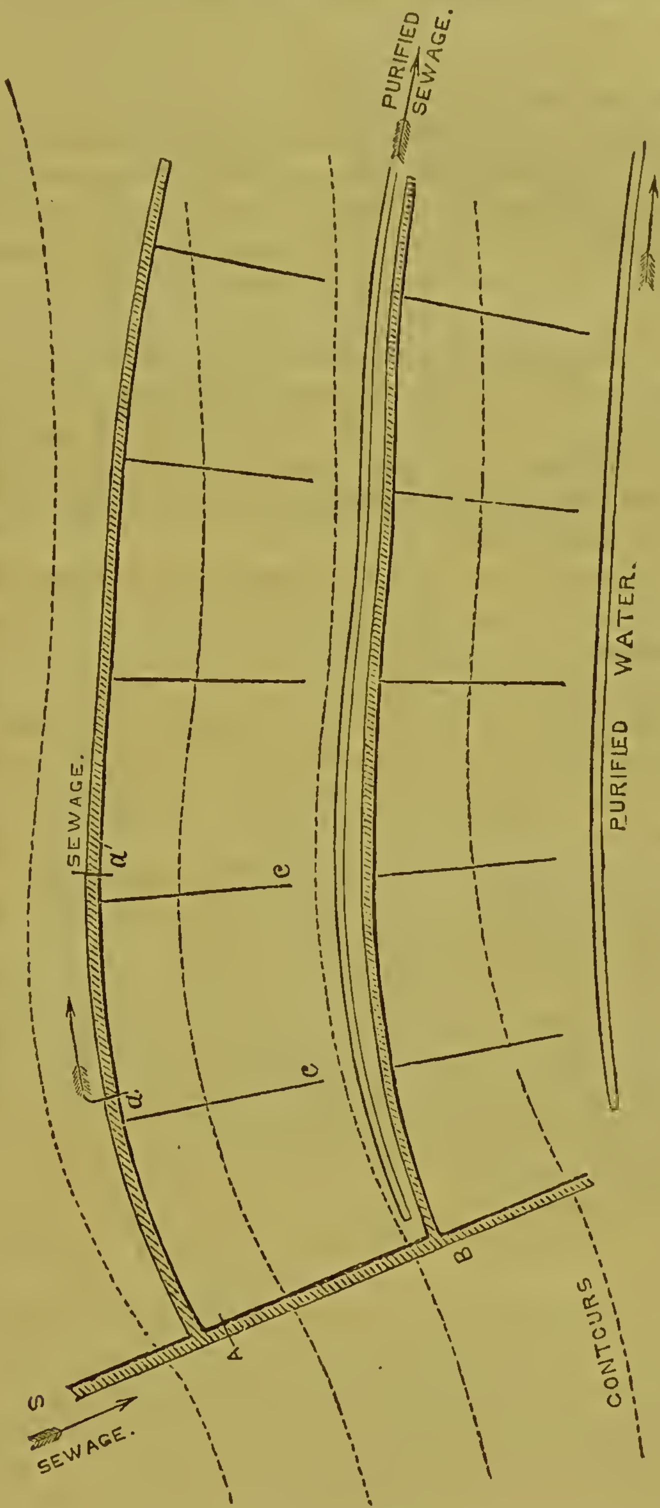


Diagram of the Channels (Croydon and Norwood).

a, *c*. A board being used in the latter at different points from *a* to *c*, makes the sewage overflow the ground right and left till it comes to the tail *c*, when after flowing over 25 yards or so of ground, it falls into the catch-drain, and is either conveyed away or utilized on ground lower down.

The board *a* is then moved to *a′* &c., and when all the higher part has been irrigated thus, then the board A is removed to B,

and the sewage discharged over the lower channels as before. Permanent traps of masonry, with wooden boards, are made to some of the main feeders.

The gradients at Norwood are as steep as 1 in 76 in stiff clay, and as great as 1 in 1,000; 1 in 117 at Beddington in gravel, and the average 1 in 250.

Arrangements are made for screening off the grosser parts of the sewage by catchpits at one part, and by a coarse filter like a floor of wood, having large holes, covered with burnt clay, through which the sewage rises upwards, leaving the larger masses below in a cesspool.

This filter is of the coarsest description, and does not provide for anything beyond the retention of the grosser impurities, which would choke the feeding channels and become offensive. The screenings are afterwards taken out and dried in the sun and used for garden manure.

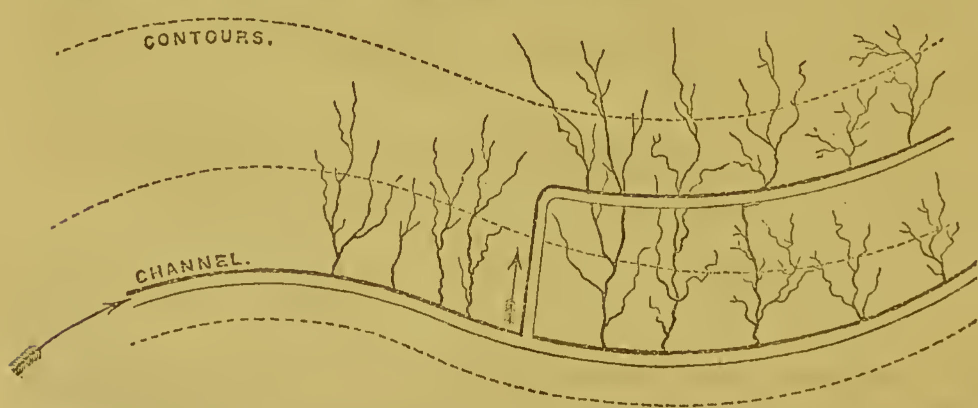
In the congress papers, Leamington, it is shown by Mr. Latham that the sewage results were as below:—

	Inorganic.	Organic.	Total.
The ordinary water supply of Croydon - -	20·02 grs.	1·09	21·11
Sewage after passing over the land - -	22·1 grs.	2·58	24·68

Rugby. Population, 7,500.

Sewage is disposed of in irrigating about 65 acres.

There is a good fall from the town, and the sewage is received from one 12′ high level iron pipe and one masonry low level one 2′ 2″ diameter, with simple earthen pits which arrest some of the coarser parts of the sewage that come down, and which are treated with ashes or some other deodorant. The clearer liquid portion is distributed over the surface of the ground which lies on the banks of the river, by simple channels.



No difficulty was experienced in disposing of all the sewage over this area. The ground is irregular, and the channels are laid out at different distances apart. No pumping is required. Some old pumps that were formerly used in a hose and jet system are

going to ruin a little distance off. The ground is earthy, with clay below, and the lias formation below that again at no great distance. The water from the purified sewage flows into the river pretty clear and unobjectionable. The meadow close to the bank of the river when the crop had been just cut seemed sodden and heavy, but it was ascribed to the rainfall.

Rye grass was growing, being the only crop tried, and it looked luxuriant enough. Five crops are got off it, and sewage is only applied once to each crop. The grass, sold green, was fetching 8*s.* per ton.

There was no perceptible odour, the channels looked black, and would doubtless smell in hot weather.

The surveyor thought that three years was the time that a field of rye grass would yield without re-sowing, and that between the crops a root crop ought to be got out.

No objection had been made by people situated lower down the river, and the operations as regards purification of the water appear to have been quite successful.

WORTHING. Population 5,800.

Worthing, on the south coast.

The sewage of this place can be delivered by gravitation into the sea, but of late years it has been granted to a company for the purpose of applying to the land, being pumped up to a height of from 30 to 33 feet at the expense of the town.

The average flow is 180,000 gallons per diem, and it is delivered into a well by a 3ft. barrel drain, where a good deal of the solid matter is deposited, whence it is raised by pumps worked by the same engine that raises the water for the town from the deep chalk formation below.

There are three pumps arranged on the same crank, the stroke being 2 feet and diameter 14 inches. The chief feature in these is the bucket, a simple flat piece of leather covering the circular plunger, free to rise at the circumference, on the down stroke.

The engine is 16-horse power, single cylinder, and high pressure. Storer's patent lubricator has been applied to this, which seems an excellent one.

This engine being also used for the waterworks, raises the supply for the town 110,000 gallons 110 feet high. The coal used (small) 18 cwt. a day, mixed with 30 gallons of tar to the ton.

It is worthy of notice that the sewage water is used instead of the fresh for the boilers. The latter coming from the chalk is very hard, the former quite soft, and brings the scaling off the boilers if used after the hard water.

If hard water is used, the boilers require cleaning once in six weeks, but if sewage is used, once in four months suffices.

The sewage after being raised is passed by earthenware pipes to the farm of the company situated on the slope of a rivulet basin. There are shafts at every 200 or 300 yards for air, the actual necessity for which was clearly demonstrated by the

sudden turning on of the flow, after being temporarily cut off at the engine house.

The water when turned on compressed the air in the drain pipe, and that acting as a cushion prevented the flow and forced the water up to the level of the head. It made its appearance like a fountain out of the air shaft. Hence it is obvious that outlets for the air must be made at frequent intervals of a pipe for conveying any intermittent supply.

The sewage has been utilized for some seven years or so at this place. The soil is a stiff marly one lying immediately over the chalk. The farm contains 100 acres. The sewage is delivered rather clear and is stated to be all required for the land.

It is conducted in open channels when it reaches the farm, which is perhaps a mile from the town, and I perceived less odour from them than in other instances. I observed very little thick and flocculent matter like that at Croydon, though it was about 12 o'clock in the day and no rain. I imagine that a great deal of this is kept back in the pumping well.

The system of channels appears to be by carriers along the highest parts of the land, with secondaries from them running down the greatest slope of the ground. The latter have to be stopped with planks or sods to get the sewage on to the neighbouring plots at different places as required. (See Croydon.)

The farm is entirely attended to by one man to irrigate, one to mow grass, one to attend to the cows and horses.

The chief crops were, of course, rye grass, growing, it is believed, 1½ cwt. to the rod, selling for 1*s.*, the purchaser taking it away himself. Five crops a year are produced, and it is found necessary to break up the land once every two years, and take out a crop of roots or oats. Wheat had not been tried. Cows and sheep had done remarkably well on the grass, and I was informed that cattle showed a marked preference for the parts of meadows which had received the benefit of sewage over those that had not done so.

The rye grass on the fields was in some cases in full ear. I was informed that mangold would take sewage very well, that turnips would not. Cabbages were thriving in one field which had received a small dose of sewage when first planted.

It was usual to sewage the land before sowing a crop of oats, &c., but not after.

The system recommended was—

2 years rye grass with irrigation.
1 wheat or oats without ,,
1 roots without, but with stable or cow dung.

It was confidently thought that this would conduce to the enhancement of the quantity of rye grass when it should be sown again.

And now I must notice a feature which, as it is considered impossible by many, may be noted as important, viz., the making of hay from the sewaged grass.

There were some fine ricks on the ground, and one just being trimmed off.

The smell was delicious and as sweet as that from any hay. About $3\frac{1}{2}$ tons of grass go to the ton of hay, but this proportion will vary with the state of the grass at the time of cutting.

I was informed that the hay must be stacked damp enough for it to heat thoroughly, or the hay will be very indifferent, if not worthless.

A probing iron left in a newly formed rick for a short time will show the degree of heat within, and it were better to run the risk of having to turn it all over than not have a proper heat.

Thrusting my hand into a newly formed rick I was surprised to find how damp it was within. No provision was made by a basket cylinder or otherwise placed in the middle of the rick, by opening which some of the heat could have been got rid of, but some such arrangement would probably obviate the necessity for turning over the rick in case of too much heating.

The grass was mown by machine or scythe, and there are tossing machines for making the hay.

It will be noticed that the time taken up in making the hay is so much lost in the reproduction of the next cut, as the ground cannot be sewaged till the hay is taken away.

The water passed off appears quite pure, and though the farm is far enough from the town to prevent any nuisance, I cannot think that even this condition is necessary to the well-being of the town. The remark was made that there was at no time as much smell on the farm as there is in any ordinary farm yard in the kingdom, and from this inspection I can quite concur in the probable correctness of the remark.

The Farm at Barking, near London.

This is worked by a company. The sewage is raised by an ordinary 25 horse-power agricultural engine from the main sewer, and forced up a pipe about 30 ft. high, and from a distance of perhaps a mile and a half. The diameter of the pipe is about 10 inches, and the discharge as then working about 300 tons per hour.

The original scheme proposed to raise sewage and supply farmers at a given acreage rate, all along that portion of the northern bank of the Thames included between their highest level and the river, and terminating at the Maplin sands on the sea coast.

The tailing water, if any, was to be utilized on the sands, which had been found to be practicable and remunerative elsewhere, as at Edinburgh.

Farmers, however, required evidence that the waters of the main drain would perform the wonders promised and the experimental farm (Lodge farm) at Barking, was started with a view of affording them the opportunity of judging.

It has been in action two or three years, and some farmers have availed themselves of the sewage after seeing what could be effected by it.

The farm consists of 250 acres. The soil is a light, rather poor, and gravelly one, and I imagine is that underlying the London clay. It may be remarked that the ground around London is generally found to consist of clay in all the low-lying districts, and gravel in the high.

On the former the cultivation is very excellent, being maintained at a high pitch by constant manuring for the produce of market gardens to supply the metropolis.

The latter requires a great deal more manuring than the former to produce the same results, being a much lighter stony soil. Yet no other manure than that of the sewage water has been employed on the farm, and remarkable results are certainly obtained.

The system of distribution of water (sewage) is that of open earthen channels supplying the fields at such a level that the sewage will run into the ridge furrows, over the ground, and into the tail furrows without any great attention. The system is therefore the "ridge and furrow." It is found that the furrows are, however, of no use for carrying the surplus water away, the soil being so porous, and a deep drain 10 inches diameter receives most of that which sinks into the soil, and discharges it pure and as clear as crystal.

As regards the *smell* from the sewage, nothing approaching the odour of a drain in a tropical climate was perceived. At the head of the delivery pipe the sewage was poured in a large volume, and here some odour was manifest. Along the course of the feeding channels some was evident, though far from oppressive. Over the land just irrigated none could be perceived, though the day was favourable for the production of effluvia, being somewhat sultry for the time of year. I was informed that the sultry, close, damp, hot days of summer were those on which the greatest amount of odour was experienced, and not when the sun was most fierce. I could perceive no possible objection in the way of smell that could be urged as likely to be detrimental to the workmen employed on the farm, and I was assured that there really was none.

The favourite crop appeared to be rye grass (Italian), and the most profitable manner of disposing of it was stated to be by cutting green. Nine cuts during the year were got from the same meadow, and the weight was stated to be under 50 tons to the acre per annum. Two floods of sewage were required to each cut; one directly the previous cut was cleared away, the second when it was half grown. Seventeen days was sufficient time to grow a crop knee deep. It was found that in consequence of the forcing of grass at this extraordinary rate it was necessary to sow the fields fresh every year, or else the plant became thin and poor.

The system of irrigation from sewage is intended by the company to supersede the ordinary rotation of crops as practised generally, the four or five year system, and the experiments are being pursued with a view of testing the practical working, the same straw crops being planted on the same ground. The necessary time, however, has not yet elapsed to prove this. Some fine

garden produce in the way of cabbages was visible on one part of the ground. The general appearance of the farm was that of a delightfully irrigated meadow, and an interesting feature the *total absence of weeds.* In this respect the cultivation resembles very much the weedless fields of India, where vegetation proceeds to grow so rapidly, that, as in the case of the Barking farm, weeds have no chance.

The financial results of the farm of course could not be ascertained, nor could that be expected as it is an experimental farm, which has not had time to produce accurately measurable results.

The arguments advanced by the promoters appear to be that the sewage will restore every fertilizing agent to the land, so that the ordinary rotation of crops may be dispensed with, and any succession of crops sown. That the method of applying the sewage directly on the land is the cheapest that can be adopted, and that any mode of deodorising destroys the virtue of the sewage, and any system of manufacturing into a dry manure is only an intermediate and useless expense before it reaches the land.

Edinburgh. Population 170,000.

A paper by Charles Macpherson, C.E., burgh engineer of Edinburgh, shows that the greater part of the dry refuse of the city is sold as manure. It is collected *daily.*

The annual amount collected is 50,000 tons.

The police byelaws provide that "every offensive matter or "thing shall be taken in pails to the streets or courts to be "emptied into dust carts by scavengers or carters, under penalty "not exceeding 40*s.* for each offence."

Sixty-five carts or waggons are employed in removal of this, twice daily (morning and evening) in the old town, and once (in the morning) in the new town.

The cleaning occupies about one hour at each of these times for each of the towns (the old and new).

The actual cost of this annually, after deducting 8,072*l.*, the sum realized by sale of manure, was in 1866 9,556*l.*

The greater part of the manure thus treated is that from dwelling houses, namely, ashes, vegetable matters, refuse of food, also horse droppings from street sweepings. The dust and sludge from the streets is excluded as much as possible and deposited separately elsewhere.

The fluid refuse is taken away by the sewers and drains.

In respect of these, one or two points are referred to which it will be well to bear in mind, viz., that the junctions of some of the branches with main sewers in the old systems were found to have been made at right angles, and in consequence the opposite sides of the mains in many cases were undermined and washed away.

The common cesspools for preventing stinks from entering the house drains were very defective, being made of rubble, stone, masonry in mortar, and becoming defective very soon they allowed

the gases to escape by the chinks of the masonry, or where rats had bored their way, and moreover the large surface of decaying deposit in them was a source of smell on the house side of the trap.

The advantages of the glazed stoneware syphon pipe are obvious.

The improvement in the stoneware pipes of late years has led to their adoption for branch drains. Over 11 miles of these have been laid since 1853 of not more than 12 inches diameter.

The sewage has been for many years devoted to irrigating the meadows for grass crops, and at present 336 acres in all are irrigated in different localities.

All descriptions of soil are irrigated, including a part of Figgate Wiggins adjoining the seashore, composed of pure sand covered with a rich loam varying from 1 inch to 4 inches in depth, entirely derived from repeated applications of sewage, no soil having ever been spread over it.

The system of irrigation is the pane and gutter.

The irrigation is begun in February, and about a quarter of an inch of sewage (in depth) is allowed to flow over the ground for 24 hours, 10 days afterwards the same quantity for 12 hours, and a third dressing or soaking after 10 days more, care being taken not to soil the partially grown grass by the latter operation. This is the whole process for one crop, of which there are generally four per annum.

It is important to remark that the land has been drained (with the exception of the Figgate Whins sand) thoroughly at 4 feet deep. Shallower drains when tried, drew off the sewage without letting it reach the furthest portion of the plot of ground.

The grasses grown are Italian rye, which requires to be resown every third year; and meadow grass, which has not required resowing even in the Figgate Whins, where it has been laid down 40 years.

The irrigated ground is let off in small plots or squares for the season to the highest bidder.

The whole grass is eaten by 3,100 cows, but after the fourth crop has been cut sheep are turned on some parts of the ground for a fortnight. They do not, however, appear to thrive, though the food is plentiful.

The grass is found to suit cows, the attempts to use it for feeding other animals having been found not to answer, and the cost of turning it into hay being proved to be such as to render the process unprofitable.

The price paid for plots varies from 40*l.* to 15*l.* or 20*l.*

As an interesting fact it is mentioned that the whole cost of the sewers has been 96,000*l.* Assuming that the annual rental of the land (250 acres) previous to irrigation was 5*l.* an acre, raised to 25*l.* after irrigation, the difference 20*l.* is the increase in value, giving 5,000*l.* revenue, and five per cent. on the cost of the sewers.

It may prevent misapprehension to state that in no case is the whole sewage of any of the streams absorbed even when the water

is applied as largely as possible to all the meadows along their course; and no irrigation is carried on from September till February, or while the sewage is much diluted with rain-water. At such time the whole passes to the Firth of Forth without being used.

The city derives no pecuniary advantage from the irrigation, and indeed the authorities proposed to try in 1839 whether the system could not be stopped, the exhalations being considered by some injurious to health. However this may be, there is no doubt that the *feeders* for the sewage are most offensive, but so far as can be judged by the senses it is from them alone that the emanations come.

Great improvements could therefore be made easily by using a non-porous material for the channels.

The pamphlet concludes by stating that the irrigation near Edinburgh cannot be profitably extended without a more extended market for the grass produced, and that therefore some simple mode has yet to be discovered for profitably applying to other crops the valuable fertilizing properties contained in the sewage.

Aldershot.

The sewage of the camp at Aldershot, with a variable population of perhaps 18,000 men (and 4,000 horses), is for the most part utilized on a farm of 70 acres, situated near the north camp, to which the flow is entirely by gravitation.

The farm is the property of a private individual, who undertakes to utilize all the sewage delivered there. During the winter months the number of men and horses is considerably less, and the flow of sewage is consequently much diminished.

The camp is well drained, and is situated on the gravelly and sandy drift overlying the chalk, on a rising ground. The flow of sewage is rapid, and is delivered probably at the rate of 600 or 700 tons over the soil which is most sandy. The soil is a mixture of the finest sand and oxide of iron in its original state, and will bear hardly a blade of grass in the neighbourhood of the farm, yet as seen from the rising ground of the camp the farm lands irrigated with sewage form a beautiful oasis in the desert of dust and gravel. Crops of rye grass, potatoes, beet, French beans, turnips, and mangold, are flourishing here, and ricks of sweet smelling hay, made from sewaged grass, testify to the perfect practicability of haymaking with this grass.

The sewage is screened through some rough wooden screens and upward filters, the latter consisting of plank floors with holes in them, before it is allowed to flow over the land. The pit for this purpose is 5 or 6 feet broad, and 20 feet long perhaps. The solid parts of the sewage which have not been broken up in the passage through the drain, together with paper, rags, &c., are quite retained here, the pit being nearly filled in the day with the refuse.

This refuse, I was informed, had been tried as a manure, and proved to contain *some* though very little fertilizing power, and

it was alleged that all the soluble salts had been washed out into the water of the sewage, which thus contained all that was valuable.

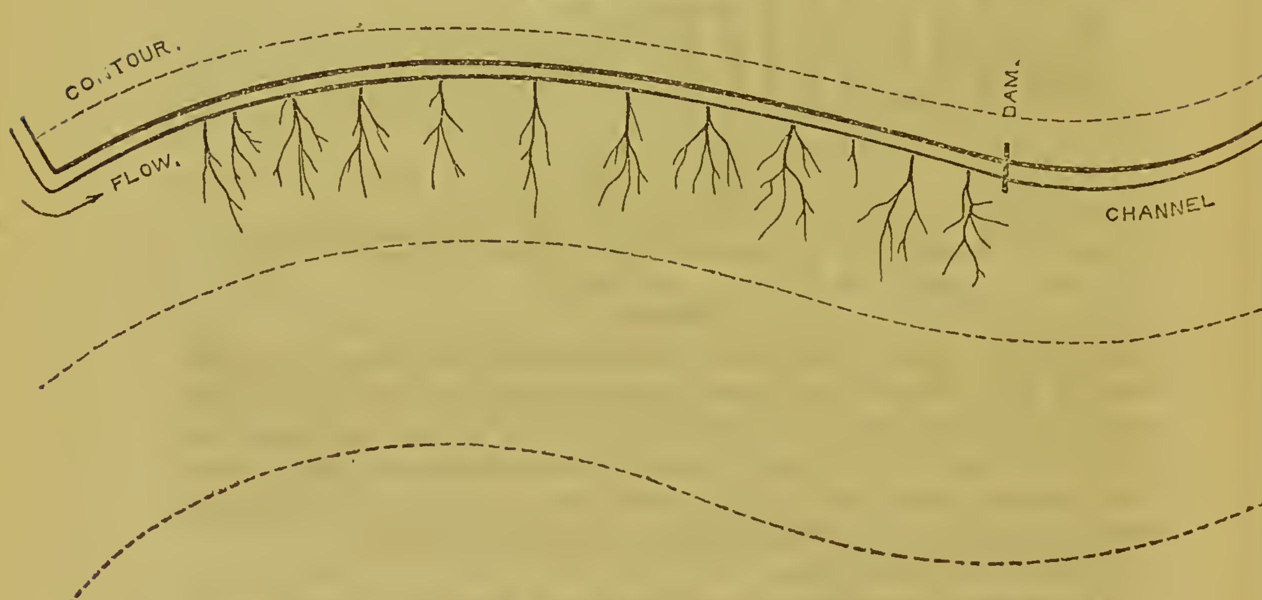
On the completion of the day's operations, the sluice holding back the solid parts of the sewage in this filtering pit is opened, and the whole, together with a lot of liquid to aid in the flow, is allowed to run down a channel with a good fall into an earthen tank, where it is kept in the open air to get dry, without any addition of ashes or deodorant.

The day was an intensely hot one, and considerable odour was manifest from the channels, and sewage, where lying exposed in any quantity, when standing in its immediate neighbourhood.

The sewage seemed to be the most offensive I have smelt anywhere, though I cannot say that the odours penetrated to any great distance; and I was informed that no complaints had been made from any persons in respect of the nuisance either in camp or elsewhere.

The principal feeders are laid out nearly parallel with the contours of the ground, having, however, a fall of 6″ in 150 yards. Perpendicular to these contours the ground has a good fall, so that the sewage is passed over the land direct from these channels by stopping them at intervals, which causes them to overflow all along the channel.

For Grass Land.



The advantage of the good fall in the ground is great, for the sewage travels quickly, taking with it the heavier particles, and the fields are irrigated quickly, and equally all over. The surplus water does not flow away by any definite channel, the soil being so sandy it sinks into it, and is lost sight of.

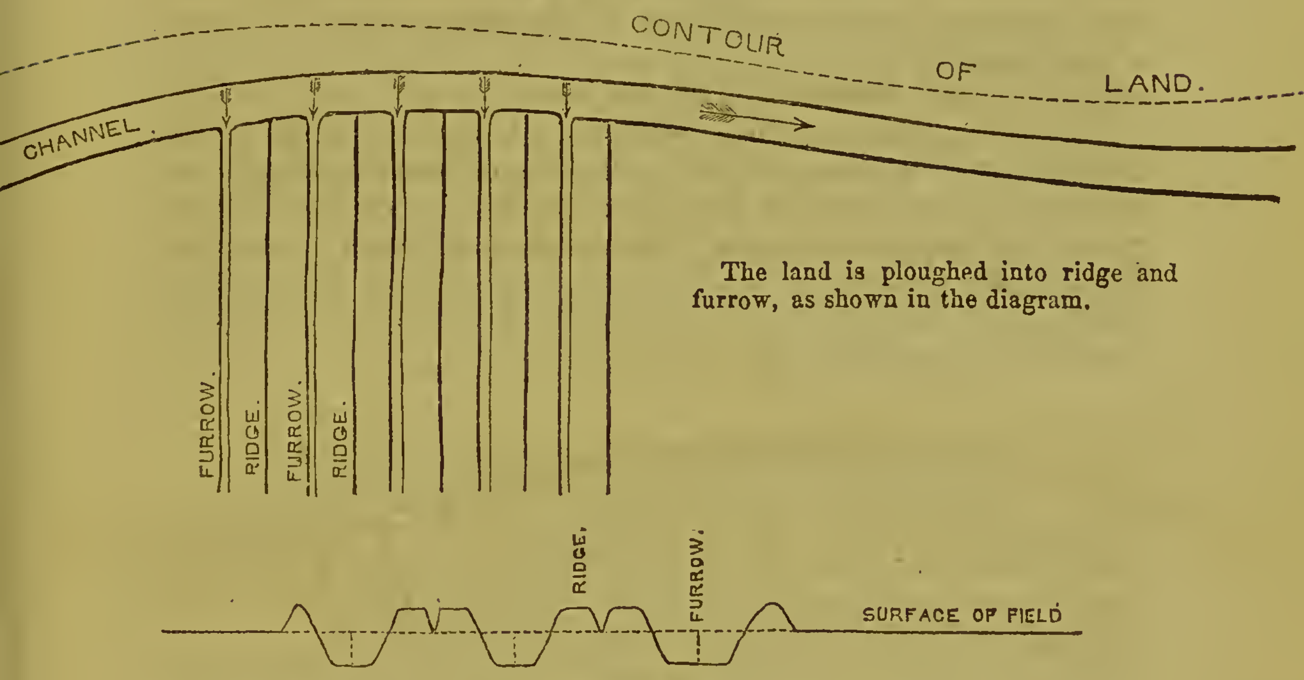
The quantity of grass got off the fields is about 15 or 16 tons for one cut, and six cuts are obtained per annum. The green grass is sold at about 1*s*. per rod. It is cut by the farm people, but taken away by the purchaser. The produce is perhaps 2 cwt. to the rod.

The hay made is stated to require five tons green grass to the ton of hay. It is put together damp, heat being essential to the proper making of the hay. The rick on the ground had been turned over once from heating too much.

The practice is to take two years' grass and one year's roots out of this ground. Oats and rye had been grown with success, but were not found to be so economical as other crops.

For grass crops, irrigate after every cut once, but not till after two or three days, to allow the young shoots to start, and be careful not to let the sewage flow into the tubes of the cut grass, or it will perish. After two years grass, the land is ploughed up, so that it is simply turned over (with a skim coulter), with the grass underneath, and sown to a root crop, and the method of planting these is as follows:—

For Root Crops.



The land is ploughed into ridge and furrow, as shown in the diagram.

Section.

The plough passes down each furrow twice, throwing the earth towards the ridge to be formed; the seed is sown by a machine after the furrow has been irrigated, and the plough is then run along the ridge as shown above, and the earth turned back again over the seed right and left, for crops which will stand irrigation after they are out of ground, such as turnips, mangold.

But with regard to beans, beet, and other plants of that nature, it is essential to have them on the *ridges*, so that the sewage when

Section.

applied in the furrows only, may reach the roots without touching the plant above ground at all, and this seems to be the one great thing to attend to.

It is found that directly the sewage touches the collet of the plant, or that part of the stem just above ground, it is burnt up and turns red directly.

But now in growing potatoes no irrigation is possible after the seed is in the ground. After the previous crop of rye grass has been cleared, and the ground ploughed up, it is usual to sewage it, and let it remain for the roots of the grass to rot, and after the potatoes are in the ground nothing more can be done. About three bushels of potatoes per rod, or eight tons to the acre, was the usual crop, and the sort grown was called "Early Shaws."

I was informed that the strength of the sewage should be varied according to the heat of the weather, and that in a hot climate it would require considerably more dilution than in a cold. In Scotland an instrument similar to that in use for testing the specific gravity of spirits had been in use for ascertaining the comparative strength of sewage, but the practical effect of applying sewage not diluted enough was very soon seen by the burning up of the grass to which it was applied.

I was informed that three gallons of sewage to the square yard of surface had been applied in Scotland, and considered sufficient.

This farm has received the benefit of the camp sewage for five years, and appears to be a thriving one. The people working on it, and especially the Scotch bailiff, were most healthy and jolly looking, and he has been in attendance ever since the irrigation has been in operation.

Carlisle Sewerage Irrigation Works.

The site of these works is situate about five-eighths of a mile from the market place in a north-westerly direction from the city, and is surrounded on three sides by the rivers Eden and Caldew, and on the fourth side by the North British Railway.

These works were designed and constructed by Mr. H. U. McKie, in the year 1860, at that time city surveyor, on behalf of Mr. A. McDougall of Manchester, who has leased the whole of the sewage of Carlisle for a term of 15 years at the nominal rent of 5*l.* per annum.

The total population is about 31,000, but the whole of the sewage is not at present used for irrigation, owing to one district, containing about 9,500 inhabitants, delivering its sewage into the main outlet sewer below the site of the engine works.

A four horse-power engine working one of Gwynne's centrifugal pumps lifts the sewage from a well in connexion with the main outlet sewer to the height of about 12 feet, and delivers it into an open trench constructed along the side of the river embankment with an inclination of one in 1,100; the sewage is then distributed where required by means of moveable iron troughs 12″ by 8″. Previous to pumping the sewage is deodorized by lime water and carbolic acid in the proportion of one gallon of the fluid to 40,000 gallons of sewage at a cost of about 25*l.* per annum.

The sewage is distributed over the whole of the land, in extent about 110 acres, about four times per year, the subsoil of which is sandy and very porous, allowing water freely to percolate, and is laid down in ordinary pasture and entirely grazed.

Mr. McDougall has sublet the whole to Mr. M. Hetherington, an extensive sheep farmer and butcher of this town, and the cost per acre is about 10*l.* per annum, including all working expenses. The value of the land previous to irrigating was about 4*l.* per acre, and is now let at 8*l.* per acre.

The natural grasses have not been made any coarser through the irrigation works, but have increased in fineness and quality, and the sheep and cattle eat it readily.

Banbury. Population 11,000.

The sewage of this place is utilized on a farm of 138 acres belonging to the town; of this, 120 acres are under irrigation.

The works were started in 1867.

There was last year a profit of 90*l.*, including the cost of pumping, exclusive, however, of the instalment of 250*l.* in respect of the 4,000*l.* borrowed to carry out the works. If this latter be included, then the cost would be about 160*l.*, or 3½*d.* per head of the population. The sewage after passing over the land flows into the river in a state perfectly satisfactory to the millowner by whom the injunction against the town was obtained.

PRECIPITATION and DEODORIZATION.

Lime Process.

Leicester. Population 68,000.

The sewage of the town is treated with lime, which precipitates the solid part, and the liquid is then allowed to flow off into the river.

The lunatic asylum is the only exception, which disposes of its sewage in irrigation, and provides thus for about 500 people.

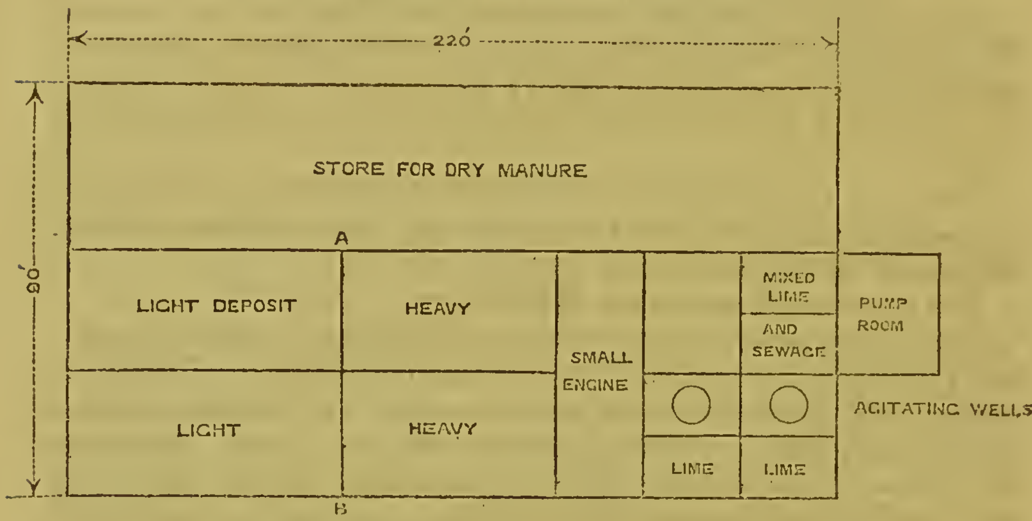
Nearly all the streets of the town are sewered to an average depth of 11 feet. The sewers vary in size from 12 to 36 inches, all of which fall into an intercepting sewer, which conveys the whole of the town sewage into an artificial outfall formed by the engine well of the pumping station, situated on the bank of the river about a mile from the town. There is also a flood sewer for carrying storm waters to the tail of a mill stream a mile lower down the river.

At the pumping station the sewage, amounting to four millions of gallons per diem, is lifted about 20 feet by two Cornish single acting engines of 25 horse-power each (nominal). The cylinders are 8 feet long and 25 inches diameter, make 12 strokes per minute, can raise 32 million gallons a week, and burn only 18 or 20 tons of coal in that time.

The pumps, of which there are *one* to each engine, are simple, with hollow piston containing 200 gallons.

The machinery is so constructed that on each stroke of the engine a *small* pump is worked which injects a certain quantity of cream of lime into the large sewage pump discharge, where it falls into the agitating well, when it is thoroughly worked up before it flows into the subsiding tanks, of which there is a duplicate set.

Diagram of Plan of the Building.

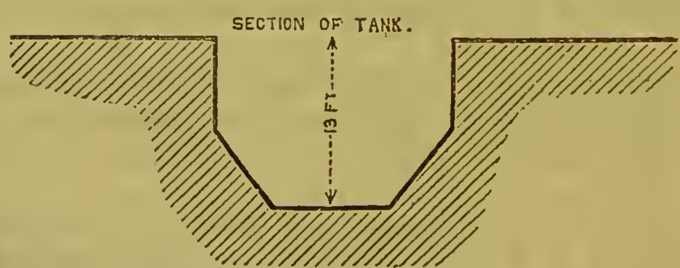


A B, a grating.

7 to 12 oz. of quicklime in solution is used to every stroke. It will be seen from the diagram that all the apparatus is in duplicate. The two places marked lime are where the dry lime is kept, and the wells are for mixing it up with water for use in the small pump. When one is being used the other is being prepared.

The tanks marked "Mixed lime and sewage" are to receive the discharge from the pump-room, and pass it on into the tank marked "heavy," whence the finer part is strained through gauze into the "light."

The lime causes a mechanical precipitation of the solid matter in the tanks, one of which is being filled while the other is being emptied, which is effected by a system of buckets on an endless rope.



The tank bottom having a slope towards the pump, the solid residuum is urged towards the lifting buckets along the bottom by a screw.

This residuum is lifted into troughs, which convey it in the semifluid state to large embanked reservoirs in the open air, where it is suffered to remain till dry, which takes about two years!!

The water flows off at the further end of the settling tanks after depositing its lightest parts held in suspension. This water though clear, could not be said to be inodorous, and I was informed that in warm weather it was far from sweet. The odour round the works was far from agreeable, and the men employed were not said to be healthy or to like the work, extra inducements being requisite to enable the amount of labour to be procured. The residuum when dry was taken away by farmers, the price realized by the town being only 1*s.* per ton, but at *this* low figure it was found a matter of some difficulty to get quit of the stock on hand.

Chemical analysis had shown that the manure possessed an agricultural value of about 12*s.* per ton, and it probably stood the farmer in that sum when it was on the field.

The town of Leicester has the advantage of a double system of sewers, for it appears the town was drained to the low level recently, and that the old high level was allowed to remain. The latter receives the rain and surface waters, and in consequence prevents all the heavy débris of streets entering the low level. Junctions are, however, made between the two systems at various points, and in all cases near the old outfalls, which prevents the foul water from the old sewers finding its way into the river, and none passes by these latter junctions until they are surcharged by heavy rainfall, when the drainage is so diluted as to be considered innoxious.

The Leicester pumping and subsiding tanks cost the town 1,200*l.* per annum.

The town is supplied with water from a storage lake 10 miles off.

Ealing. Population, 8,000.

The sewage of this place is delivered by gravitation through an egg-shaped sewer 3 ft. 7 in. × 2 ft. 6 in., having an average fall of 1 in 449. The water supply is 15 gallons per head; the sewage discharge 1,000,000 gallons. A depression in the ground near the outfall has been taken advantage of to build the settling tanks on arches, so that the emptying of the residuum can be effected through a hole at the bottom of the tanks stopped up by a valve while they are being filled.

The system is essentially precipitation by the admixture of lime and the refuse of petroleum; the latter supplying a quantity of sulphuric acid, which is considered to counteract the tendency of the lime to liberate the ammonia. An arrangement is made by which in the event of a heavy flood (3·6 in. of rain having been known to fall in 10 hours) the sewage can be turned direct into the outlet, which is a small stream tributary to the Thames.

The works have been in operation some years, and it is in contemplation to apply the same system to Tonbridge. The settling tanks are in duplicate. The sewage passes through a system of

partitions of wooden planks placed horizontally with small interstices to allow of a mechanical filtration of the grosser parts, and subsidence of the heavier by stagnation. On leaving this series of (5) tanks the sewage is passed through a straw filter previous to its passing into the upward gravel filters. This straw filter is arranged vertically, and requires renewal about every 14 days.

The upward gravel filters are arranged with perforated floors, covered with coarser burnt ballast below, gravel above, and finer gravel at top, perhaps 2 ft. thick. Since the population has increased it has been found necessary to increase the filtration area, and this has been done by constructing additional filters of wood, the filter floors of hurdle, and the medium of ballast and gravel as before.

The proportion of filtering surface and tank room is put down at a quarter of a square foot per head for the former, and 2 cubic feet for the latter; supposing the water supply to be 20 gallons a head, the usual allowance of the water companies.

These filter-beds being on timber supports are cleared through the bottom (as the settling tanks are), and require cleaning and the gravel renewing every ten weeks.

The fall in the sewage in its passage through these tanks and filters is 6 ft., but 2 ft. would be quite sufficient for the proper action.

The mixture of lime and petroleum refuse is in the following proportion: 264 lbs. of lime (two sacks), 24 lbs. of petroleum refuse. This mixed with water to measure 1,000 gallons lasts for 1,000,000 gallons, or the whole sewage of the 24 hours running constantly. The petroleum refuse is understood to cost nothing hardly.

The admixture is effected by hand in some large tubs placed over the drain inlet to the works, and allowed to flow out through the tap hole; but arrangements are in contemplation for a more intimate mixture of the precipitant by means of some simple machinery worked by the outfall water.

The action of the precipitant was shown to take a very short time in the case of a gallon treated with $\frac{1}{1000}$th part.

The residuum arrested by means of the settling tank and filters amounts to one cubic yard per day. After being drawn out through the vents at the bottom of the tank it is mixed with the ashes from the dustcarts and sold to farmers at 1*s.* per cubic yard. No difficulty is experienced in getting rid of any quantity at this price.

The cost of the works is understood to be about 150*l.* per annum. The establishment consists of about three men. The water turned out is free from smell and looks clear, and probably has no injurious effect at all after it leaves the works.

In very hot weather sulphate of zinc is used in very small quantities to deodorize the sewage. Perchloride of iron has also been used for the same purpose.

The only disagreeable odour from the works is met with in the residuum previous to its mixture with the ashes and dust for sale to farmers.

Leamington. Population 18,000.

A. B. C. Process.

The works are at present in the hands of a company of gentlemen, who have taken them for the purpose of demonstrating the efficacy of a system of which they are themselves persuaded.

The system adopted previously was that now being carried on at Leicester, viz., the "lime." Large heaps of undisposed of residuum testify to the difficulty of getting rid of the results of the process.

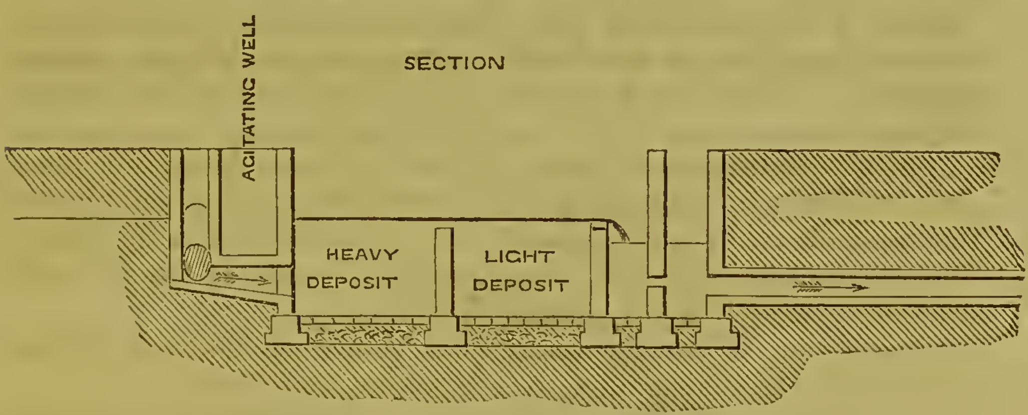
The process now going on is called the A.B.C., those letters being the initials of the three principal ingredients used in precipitating the solid part (alum, blood, and clay).

As in the lime process the object is to precipitate the solid part of the sewage, utilize it for manure, and allow the water when purified to flow into the river.

The tanks formerly used in the lime process have been found to require very little alteration for the A.B.C.

The sewage is delivered by gravitation only.

Diagram of Settling Tanks (1 set).



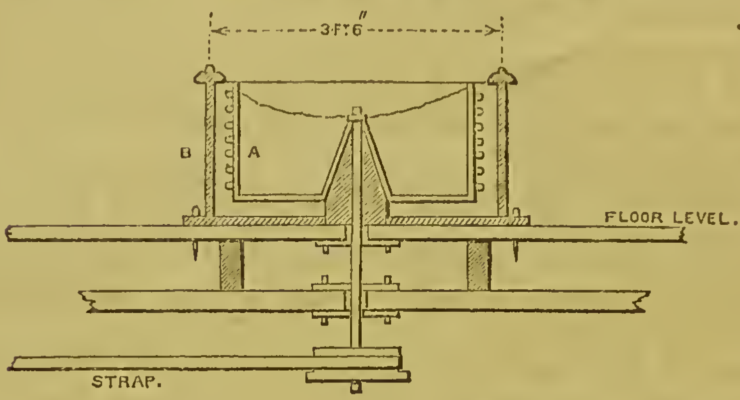
There are four sets of tanks which come into use alternately. The sewage is received into the agitating well, which is a common brick well, having an apparatus similar to that in a pug mill for agitating, and breaking up the solid parts in the sewage, and assisting in mixing with the precipitating mixture which is prepared in solution in a similar small agitator well, having communication by means of a valve with the sewage well.

The sewage and precipitant fall into the tanks, of which a diagram is given, where the separation of the solid parts is effected in a mechanical way, the heavier falling at once in the first tank, the lighter and more valuable in the second, and the lightest being skimmed off the surface in the last compartment. A further deposition is effected in the channels (open earthen ones) communicating with the river, and two or three small weirs of plank cause the *soap* of the washings to froth on the surface and be retained.

The mode of treating the solid residuum is shown below :—

DIAGRAM (SECTION).

Circular Sieve for pressing out the Moisture by Centrifugal Motion.



1800 revolutions a minute.

A, the sieve revolving on the cone; the water is forced through the upright sides of the cylinder, which is supported on the back by thick wire, and bands across. The water is caught by the outer casing B, and falling to the bottom is conveyed away by a pipe. The sieve getting choked with fine particles after a time, is cleaned by a jet of steam poured on the outside of the sieve while it is revolving, which forces it out on the inside.

There is only one main sewer; the size is 2 ft. by 4 ft. 8 in., discharging 500,000 gallons of ordinary sewage, or 1,250,000 gallons, including rainfall, in 24 hours.

The ingredients used in the precipitating mixture are as near as possible as follows :—

Clay, 4 lbs.
Alum, 1 lb.
Blood and clay, 1 lb.
Animal charcoal, 1½ oz.
Wood charcoal, ½ oz.
Magnesia, ½ oz.

9½ cwt. or ½ ton is used per diem, and being worked up in the small agitator wells with purified sewage water is used in probably the ratio of 1 per cent. to sewage to be purified.

Five tons of dried manure are produced per day, and the price obtained is 3*l.* 10*s.* per ton.

The price would vary according as it was for the residuum from the heavier deposit of the first well, or whether it was from the light. The first containing a good deal of road matter is not found to be so fertilising as the light. Were the proceeds of the two tanks kept separate, and the lighter disposed of at a higher price, which it would undoubtedly obtain, there would be difficulty in getting rid of the heavier, so it is all mixed together. The agitators and all machinery require only one small engine, 14 horse-power, horizontal, single cylinder and boiler. Tanks to hold a 24 hours' supply would be sufficient, as the precipitation of solid matter takes places very rapidly, 7½ minutes being sufficient.

The works are not kept in operation during the night, very little sewage coming down after 10 o'clock at night. The water comes out quite sparkling and clean, and contains only some slight matters visible to the eye ; it was as clear if not clearer than the river water which receives some of the sewage of small hamlets above Leamington.

Fish I was informed took every opportunity of invading the open channels leading to the river, and appeared to prefer the water to that of the river.

Some had been kept in an aquarium filled with the sewage for some weeks.

I was informed that no difficulty existed in selling the manure prepared, the farmers generally relying on the chemical analysis for the approximate value.

As regards the working of the drying mills, Mr. Wigner stated that they worked admirably, 12 charges per hour being turned out, six from each mill, and the necessity for using the steam jet for cleansing the strainer was not very frequent.

In regard to the manure itself, the report of the experiments carried on at Leicester, Leamington, and Tottenham shows the value to have been determined by Dr. Frankland at 3*l.* 17*s.* 3*d.*, and that if no acid had been added, it would have been 1*l.* 13*s.* 0¾*d.*

It may be stated that sulphuric acid is added to the residuum on its removal from the centrifugal drying machine in proportions varying with the quantity of ammonia to be fixed, averaging 1½ per cent. of the weight of the residue.

The pamphlet shows that the sewage contained 43·02 grs. per gallon ; of this the A.B.C. process precipitated 33·33 grs.

Comparing the results of lime and A.B.C. process—

Water from A.B.C. contained after treatment 9·69 grains.
" lime " " 16·18 grs.
After precipitating from A.B.C., 77·48 per cent.
" lime 62·39 of solid matter.

STROUD. 7,000 inhabitants.

Clay and Sulphuric Acid.

The works at this place take in the drainage of the portion of the town under the local Act (about 7,000 inhabitants), but a portion containing some two or three thousand more on the outskirts pours its sewage directly into the river, and is quite sufficient to render the beautiful stream a black and foul main drain. It is a fact that after the purified sewage of the former has been mixed with the river containing the sewage of the latter, the stream is considerably purer than before. The stream appeared to be some 25 feet broad here with a rather sluggish flow.

About 150,000 gallons of sewage are treated in the works, which enters in a stream through the drain about 5 inches deep and 2 feet wide. The rainfall included, the discharge will be double the above. The works are managed by a company which has a

lease of them for 20 years, 10 of which it is understood have passed.

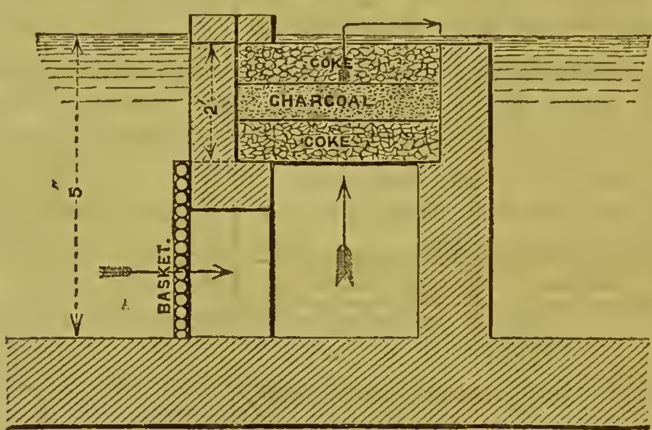
The town pays nothing to the company, and the latter only a nominal rent to the town for the use of the tanks. At the expiration of the agreement the town has to take the buildings that have been found necessary at a valuation

The sewage is received in the tanks and treated with a precipitating and deodorising powder called Bird's powder, for which a patent appears to have been granted, of which the ingredients are very simple, 1 cwt. of clay moistened with 12 lbs. of sulphuric acid, dried and ground.

A simple contrivance, consisting of a funnel-shaped box with a hopper at the bottom, scatters the powder in a continued stream on to the sewage at some little distance up the sewer, the agitation of the sewage in the short length of sewer to the tank being sufficient to mix it well together.

The motion of the hopper is effected by a small fan wheel in the sewage stream itself. The mixed powder and sewage then flows into a duplicate set of subsiding tanks (originally designed for the lime process, which of course had failed). (*See plan and section of the tanks at Stroud on opposite page.*)

Section of Filter.



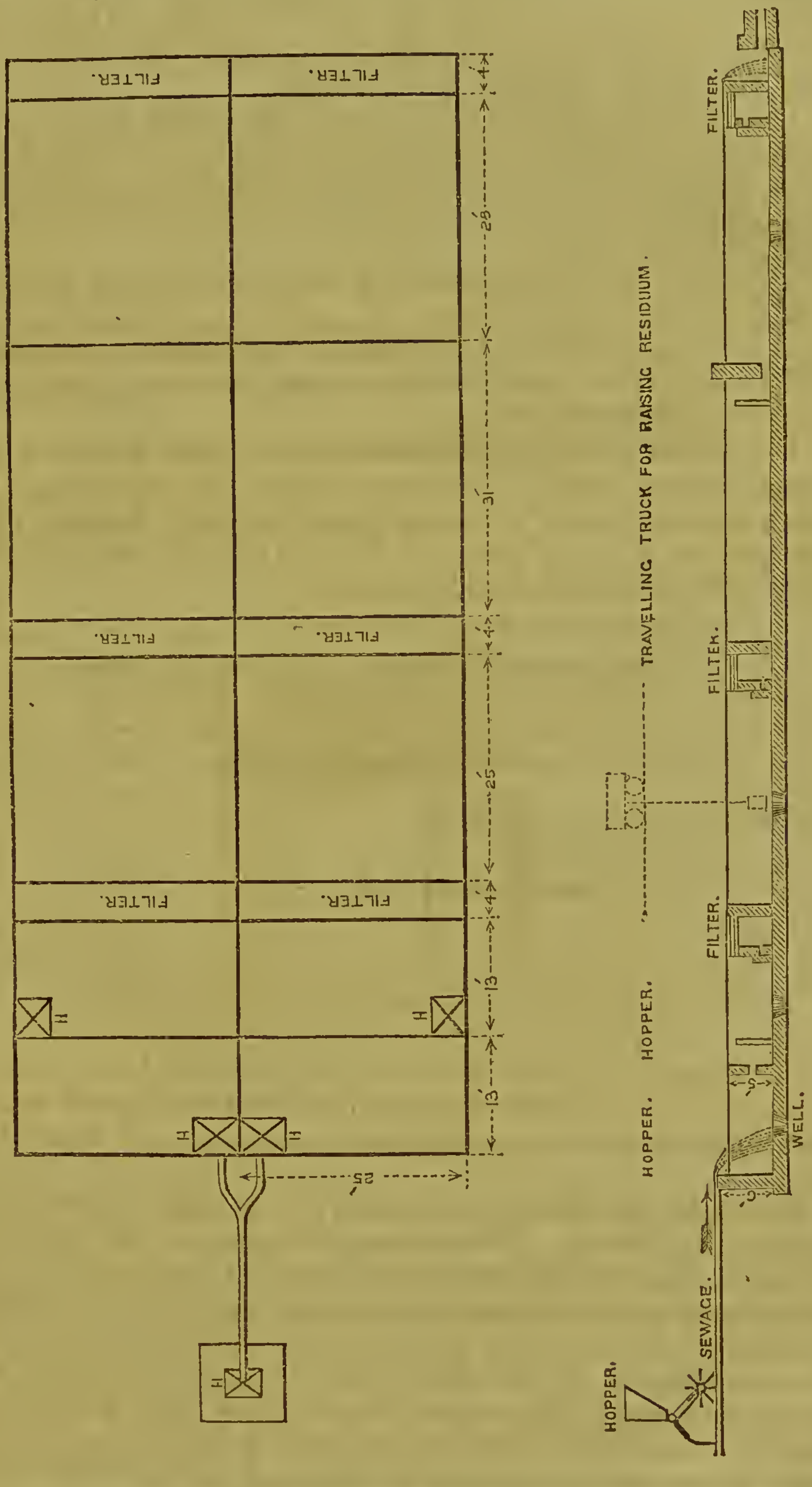
The ingredients of the filters are kept together between basket-work or hurdles. There are three filters, each is cleaned monthly. The same charcoal and coke being washed is used three or four times.

The tanks are cleaned out weekly, they ought to contain the sewage of 12 hours. The residuum is swept into the wells at the bottom of the settling tanks and then raised by the bucket on to the travelling truck, which runs on a wooden tramway over the tanks. These tanks are all in the open air, but I did not notice as much odour arising as in the case of covered tanks apparently in use everywhere else. The water flowing off is clear and unobjectionable as regards smell. The residuum in being raised from the tanks is deposited in open tanks formed of earthen embankments above ground.

Smell is prevented by a sifting of the deodorising powder over the surface of the residuum. After two or three months the stuff is dug out and used as the *basis* of a manure from which the

company derive their profit. In itself this basis is not of any great value; but by the addition of the necessary chemicals it is stated to realize a price of 7*l.* 10*s.* per ton. I saw a good many heaps

Plan and Section of the Tanks at Stroud.



of unused "basis" in the course of drying, but nothing offensive was apparent in the air.

The proportion of deodorising and precipitating powder (Bird's) used was stated to be 1 cwt. to 1,000 inhabitants. The cost of

the establishment, including all expenses reckoned on the weight of powder consumed, gave a rate of 30*s*. per ton for the cost price of the powder. Eight tons of manure were turned out per week.

It was pointed out that the precipitation of the solid part of the sewage was effected mechanically, and is analogous to that which would be effected by alum, which is in fact formed by the sulphuric acid and alumina of the clay, alum being a sulphate of alumina.

As regards the deodorising, the sulphuretted hydrogen is precipitated by means of the iron oxide in the clay, the oxygen of which goes to the hydrogen, forming water, and sulphur going to the iron, forming sulphate of iron.

The analysis of the sewage proper on 28th October 1868 gave specific gravity = 1·00041.

The residue readily subsided and the dark brown liquid had an alkaline reaction. Contained—

Mineral matter - - -	35·48
Volatile and combustible - -	12·02
	47·50

The deposit contained—

Mineral matter - - -	14·33
Volatile and combustible - -	24·64
Phosphoric acid - - -	1·97
Total solid matter in 1 gallon sewage -	86·47 grains.

The outfall water contained—

Mineral matter - -	38·25
Volatile and combustible - -	2·03
	40·28 grains.

Cheltenham. Population 43,000.

Perchloride of Iron. Filtration.

This town is well sewered, and has two outlets into small streams that might be mistaken for large ditches, the Chelt, and Hatherly brook, both falling ultimately into the Severn. The average daily volume of sewage down these outfalls is, for the Chelt 775,203 gallons, and for Hatherly 270,718. The usual complaints having been made at the sewage being discharged into these streamlets led to the lime process being resorted to in 1859, but the complaints being no less frequent under this process, *Mr. Bazalgette* recommended the use of perchloride of iron until arrangements could be made for disposing of the sewage by irrigation. This suggestion is being now carried out.

The sewage is received into subsiding tanks, where it is allowed to settle without any other addition than the deodorant perchloride of iron, and being passed through several sorts of gratings and

filters is allowed to flow away into the streamlets, not however in a very pure state. During a rainfall while I was at the works the sewage was passing through without any deodorant, the quantity being too large to treat, and considered so diluted as not to require it.

The drainage is effected by gravitation alone. There is a capital fall, and a good fall in the country beyond towards the N.W., which it is intended to irrigate.

An experiment had been made extending over five months with Bird's powder at the Hatherly tank, but was not considered to be satisfactory. This powder is in use at Stroud by the company who have patented it and who claim that it did not have a fair trial at Cheltenham.

Perchloride of iron has been in use six years.

About 30 gallons are expended daily at the Chelt.

" 10 " " Hatherly brook.

The cost of the perchloride of iron is 8*d.* per gallon.

It is poured into the drain some little distance above the discharge into the subsiding tanks, and is reported to deodorize the sewage instantly.

The subsiding tanks are in duplicate, and are ordinary brick cisterns divided into a series of compartments by transverse walls which contain alternately two vertical wooden grating filters, one upward filter and one downward filter; two overflows are also provided. In fact the interception of the solid part is effected probably very completely by these mechanical contrivances. The upward filters are constructed of perforated plank floors below with stones laid on the top. As the system of tanks at Stroud will give a pretty good idea of those at Cheltenham it is unnecessary to describe these further. The residuum when dredged out of the tanks is mixed with ashes from the scavenging department and realises a price of 2*s.* per cubic yard as manure. The average cost of the works as now carried out for three years has been—

	£776
Realised by sale of manure - -	285
Yearly expenditure over income -	£491

The principal source of expenditure in this is the perchloride of iron, which will be saved by the introduction of irrigation. It is not, however, proposed to do away with the subsiding tanks for abstracting the solid matter mechanically in introducing the irrigational system.

Cheltenham appears to be most favourably situated for irrigation, the fall is good and the farmers are disposed to use it, petitions from them having being received in 1866, representing 1,100 acres, asking for sewage to be supplied them, for which they were ready to pay 10*s.* per acre. At another time applications were received of a similar nature from the holders of 2,000 acres.

Experiments were made on a small scale at one time on 12 acres of land, which was successful; but as pumping had to be resorted to was abandoned on account of the expense. At another time, 1865–66, an experiment successful in other respects was abandoned through the objections raised by owners of property through which the sewage conduit had to be carried.

It is now proposed to extend the two outfalls to a farm of 130 acres, to be purchased by the town to serve as a reserve for the expenditure of sewage when not required by the farmers. For this purpose the Chelt extension is to be effected by a barrel sewer 27 inches in diameter, having a fall of $5\frac{1}{4}$ feet per mile; the Hatherly extension is proposed to be a 15-inch pipe, having a fall of 1 in 880, or 6 feet per mile.

The estimate for these works is 7,000*l.*, and the annual payment to pay off this amount will be 450*l.*

It is understood that the extensions will be constructed in straight lengths with manholes at every 50 yards or so, in order that the pipe may be inspected without traversing the whole length.

Experiments at Paris on Purification by Precipitation and Irrigation.

The "Engineer" of the 9th July 1869 gives a notice of a system of purification by a patent process which had been tried at Paris, which it may be proper to notice.

The experiments extended over two years, at a cost of 9,000*l.*, and were arranged to act on 500 tons of sewage per day. The precipitating agent was alum, formed by treating "kaolin" with sulphuric acid, delivered in the form of a solution, having a density of 1·074; cost being 1*s.* per hundredweight. Practically it is shown that each ton of precipitate costs 7*s.* 6*d.* for alum. The quantity employed was about half a litre per ton.

Many other precipitants had been tried, but not with equal success.

Experiments with the purified water on the precipitate showed the following results:—

Purified sewage water on grass, $37\frac{3}{4}$ tons per hectare.	On irrigated land of equal amount adjacent, $4\frac{1}{2}$ tons.
Wheat sown with $2\frac{1}{2}$ tons common manure.	Wheat sown with $2\frac{1}{2}$ tons precipitate.

Corn.—Produce the same in each case, but the *straw* yield was greater on the side of the farm manure.

The report states "that they have shown the great value of the "precipitate as a manure, and the lesser value of the purified water, "but they have not shown that purification can be made a paying "process."

LIVERPOOL. Population 450,000.

In Liverpool the sanitary officers have caused a great many privies to be converted into waterclosets. The sewage is all "passed into the Mersey. The health report states that "the "fevers in which abdominal derangements are predominant (gastric, "enteric, typhoid, bilious, relapsing) do, as a rule, prevail during "the summer months, when emanations from decomposing animal "and vegetable refuse are most abundant and concentrating; while "typhus, the disease of debility, of want, indigence, and overcrowd-"ing, is most common in wet and cold months. Thus typhus may "exist without blame to the governing body, and the removal of its "cause is beyond the duties and responsibilities of property; but "epidemic, typhoid, or enteric fever never."

On referring to Dr. French, the medical officer of health, he informed me that he had caused 13,391 privies to be altered to waterclosets between the years 1860–63, and that in that period probably 5,000 more had been altered by private owners voluntarily. They were acting under a local Act (of 1854). That provided "that when and so often as it shall be certified to the "council, by the medical officer of health, that any privy is in a "situation or condition injurious to health, it shall be lawful for the "council to require the owner effectually to remedy the same to the "*satisfaction* of the said council." The council have ruled that the only remedy to their satisfaction is alteration to a watercloset.

Hitherto the drainage has been direct into the Mersey; but a company, supported by the municipality, have undertaken to convey the sewage to a sandy and loamy soil at the north of the borough, or rather at about eight miles to the north, and there utilise it. The works are nearly completed, and they expect to begin pumping in a month's time.

Dr. French says, "Though I am an advocate of waterclosets "in Liverpool, where we have a tidal river, my certificates were "and are not based on any abstract principle as to the best mode "of disposing of the sewage of large towns."

"The Engineer" of the 8th January 1869, gives a drawing of the sewage pumps.

It states that the pump is to raise 500,000 gallons of sewage in 24 hours 125 feet high, through a 9-inch main, 6¼ miles in length.

The cylinder of the engine is 20 inches diameter, stroke 5 feet, condensing air pump 15 inches diameter, stroke 2½ feet, fly wheel 14 feet diameter. The pump is of the combined plunger and bucket type, the ram 10 inches diameter, bucket 14 inches diameter, air vessel 2½ feet diameter, 9 feet high, delivery pipe 9 inches.

In WORCESTER a requisition has been received from the town of Tewkesbury that the sewage may be purified prior to its discharge into the river Severn.

GLOUCESTER discharges its sewage into the river Severn.

BRIGHTON discharges into the sea by three sewers. The principal one opposite the centre of the town extends one third of a mile from the shore, and the depth of the sea at the point of delivery is 30 feet at high water and 10 feet at low water.

The current at this point flows east and west at an average rate of 60 feet per minute, so that the sewage is stated to be soon disposed and lost sight of. There are two other outfalls east and west of this one. About 40 miles of sewers are required for the complete drainage of the town, of which about 25 miles only have been done.

SOUTHAMPTON discharges the sewage at present into the sea, *i.e.* the Southampton Water.

They have been in treaty with a company for the deodorization by the A.B.C. process, but without being able to come to an agreement thereon.

There is at present no system of deodorization at work.

SALISBURY discharges the sewage into a branch of the river Avon. No works for utilising it have been as yet started, but the engineer hoped to be able to draw up some plan for doing so shortly.

BIRMINGHAM.

Settling Tanks.

Borough of Birmingham. Population 300,000.

Here there are two subsidiary tanks for intercepting the bulk of the sewage matter held in suspension. These have been in operation for the last 10 years, and in consequence of the water after having passed the tanks not being satisfactory to the land-owners below the outlet, a system of irrigation has been commenced, and they are now applying the sewage to various crops (principally rye grass) after the Croydon system.

No deodorant had been used in connexion with the tanks, but gypsum is used on the intercepted sewage after its removal from the tanks. Any attempt at filtration was considered waste of money. The application of sewage to *other* than rye grass crops had not been attended with satisfactory results since the irrigation system had been introduced, but the only year in which it had been tried was an exceptional one.

MANCHESTER.

Ash Pit System.

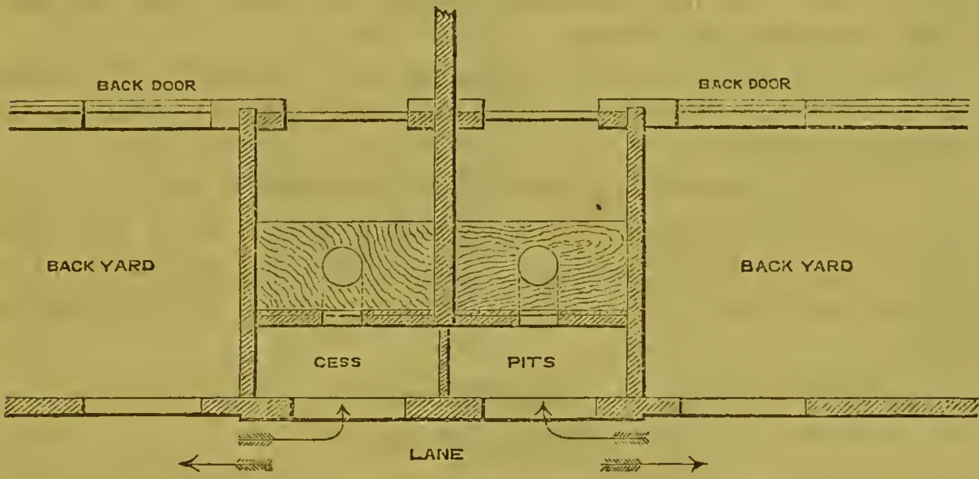
Manchester rejoices in about 400,000 inhabitants and a dirty river, into which the refuse of the manufactories on its banks is poured. The water looks black and is covered with a filthy scum, the odour from which is at times abominable.

I was informed by the superintendent of the scavenging department that there were probably 10,000 waterclosets, and that the removal of all other refuse was effected on the cesspit or ashpit system.

There were in June 1868, 82,115 ashpits, and 124,725 tons of nightsoil and rubbish removed from them during the year.

The cleansing department is required to have cesspits emptied within three days of notice being given to the district officer, and is empowered to clean them without any notice whatever, if it is deemed necessary.

The principle on which they depend in this matter at Manchester appears to be the deodorising effect of ashes from the hearths, and removal of the cesspit matter frequently.



This is a diagram of the arrangement shown to me as the usual thing. The rows of houses have a back lane between them up which the nightsoil men come to clean out the cesspits which is effected through the window-like openings at the rear of the closets, and through which the inhabitants have thrown the ashes and cinders, which should be thrown in under the seats of the privies, but I did not notice that this was very generally attended to.

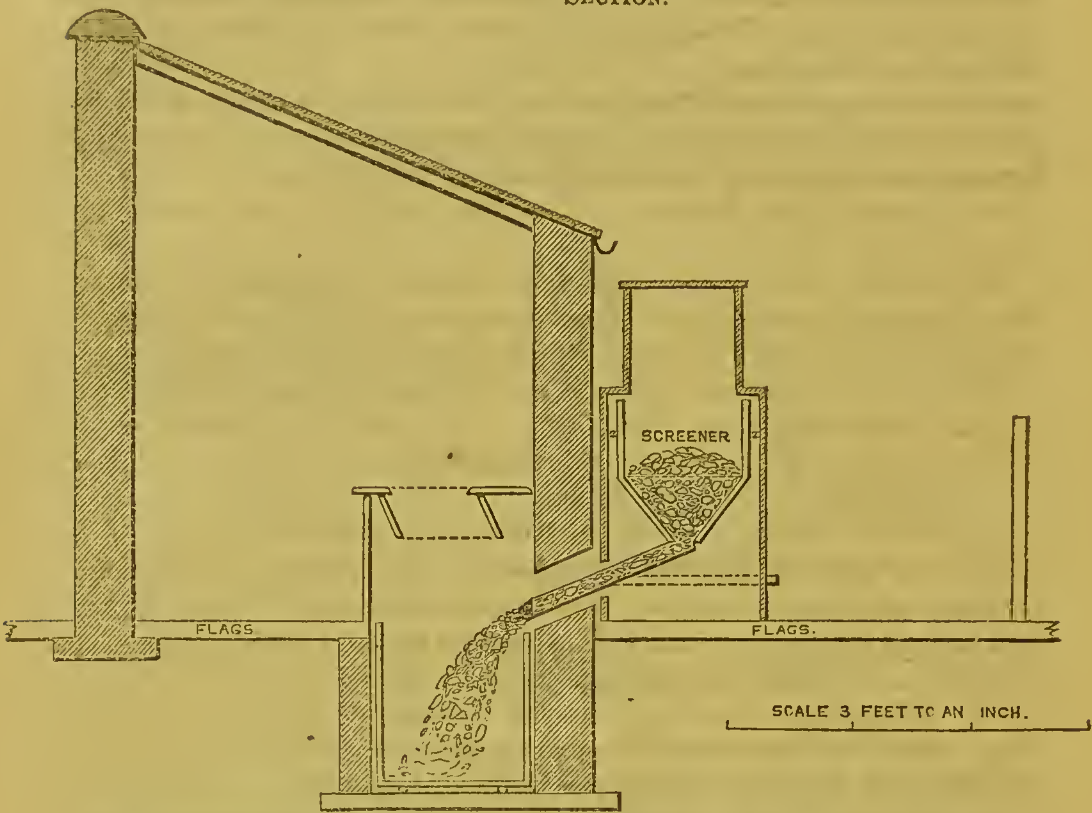
The cesspits are emptied when full, and not at stated intervals, and the time will occasionally extend to a year.

Mr. Wallworth, who has been the superintendent for some 20 years, informed me that the system had been nearly the same for as long as he had been there; though the waterclosets existed, the construction was discountenanced as much as possible. In a printed pamphlet of his he says, "I would not by any means advocate the "adoption of cess pools or pits, but I believe that no known or "projected system has yet been found to answer the requirements "of a large or small town equal to the Lancashire ashpit, where "the soil can be retained along with fine ashes and removed with "it to the land."

The system as adopted at Manchester is capable of improvement, and great expense would be saved to the town by the adoption of a few simple measures by the householders. First, by letting the ashes pass through a grating before falling into the pit, and by burning the cinders over again. Second, by vigorous exclusion of water from the ashpits. Third, by exclusion of broken mugs and other heavy rubbish of no use to anybody.

The houses have all been supplied with *house* drains for liquid refuse, and the drains find their nearest way into the river, which has been rendered by it anything but savoury.

SECTION.



Recommended by Mr. C. Murrell.—See his pamphlet, March 19, 1869.

The town has a supply of water from a lake constructed some miles off near Woodhead.

The streets are swept and the produce sold to farmers, entirely separate from the night soil, and finds a readier sale in the immediate neighbourhood than the latter, which has to be disposed of at some distance.

The method of disposal of the refuse is as follows :—

The street sweepings are collected in iron tank carts costing about 25*l.* each, swung on axles low to the ground, and provided with an excentric and windlass, so that they can be completely overturned to empty the contents. The sweeping is effected by hand. The refuse collected is stored in ricks. It contains much loose straw, &c., and is light. It is carted away by the purchasers themselves, and is sold at about 1*s.* 6*d.* a cubic yard.

The nightsoil is collected in wooden carts, 43 of which are out all night till 9 o'clock in the morning, and four are detailed for the clearance of slaughter-houses. The soil is shot at once into barges and conveyed down the river, if there is a demand in that direction, or into the town's own trucks on the railways. But during the harvest, and other times when there is no demand, the soil is stored in a large mass on the premises near the river, specially set apart for the purpose. When I visited the yard, however, I saw none in store. Rubbish, such as broken pots and pans, &c. &c., which can be separated from the stuff to form manure, is taken out at the

store-yard and carted away to the nearest place available, where filling in of a hollow piece of ground is desirable but it is a matter of considerable difficulty to find any such places within reasonable distance of large towns. I was astonished somewhat to find that the average price of the manure (ashes and nightsoil) paid by farmers was only 1*s.* per ton; but that the town was glad enough to get rid of it *anywhere,* and at the same time the ashes, which could not otherwise be disposed of, I could easily imagine. The cost to the farmers, including the carriage, of course, was much in excess of this, according to distance. The price paid by rail is 1*d.* per ton per mile.

The cost of the scavenging, cleansing, and watering the township, deducting some items of revenue, was 10,679*l.* net, giving a rate of about 1*s.* 4*d.* for every 1,000 yards of surface swept.

The cost of removing nightsoil and slaughter-house refuse was 12,207*l.*, after deducting about 3,739*l.* the value of nightsoil.

The quantity of night soil and rubbish removed was—

Nightsoil.	Rubbish.	Total.
69,468 tons.	55,257 tons.	124,725 tons.

The mortality in Manchester appears to be highest in July and August, when *diarrhœa* rises from a general average of four or five to as high as 89 per thousand. The general health shows the largest proportion of deaths amongst the children up to five years of age, which is ascribed, however, to the necessities of the working class, which prevent the children from receiving that nourishment and attention from the mothers that they should do.

A remarkable fact should be mentioned in connexion with the health of the men employed in the department, viz., that there is a total absence of cases of cholera, notwithstanding the men are even called upon to remove the beds on which the patients have died. The general health of the men appears also unimpaired.

It is understood that this system is generally used in the towns around and near Manchester.

Derby. Population 43,000.

The borough of Derby has the ordinary brick drains and sewers, with stoneware pipes. The town is well drained, and has three outfalls, all of which discharge directly into the river Derwent. Taking the population at 50,000, and allowing 25 gallons of sewage per head, there is 1,250,000 gallons of discharge per diem.

Perhaps half the houses in the town have waterclosets, the other have the old privy and cesspool. It is a fact that there are many wells in close proximity to the cesspools, which are not all watertight, from which water is drawn by the inhabitants.

A scheme is in contemplation for intercepting the outfall sewers, and utilizing the sewage in irrigation.

There are a few earthclosets at the county gaol and the grammar school, but they have not at present met with any particular favour from the authorities at Derby.

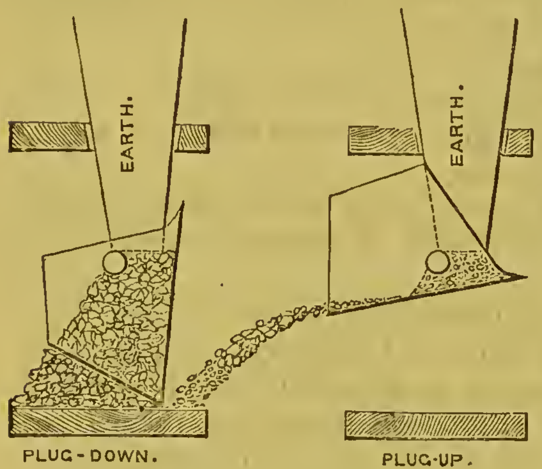
The water for the town is taken from springs, and in summer, when they fail, from the river Derwent after it has received the sewage of six or seven villages of some size above Derby.

DRY SYSTEMS.

Moule's System.

Moule's system has been advocated by many as the only one that meets the real requirements of the case. On inquiry at the office in London, I was informed, however, that it was not a system contemplated for large towns, nor practicable on a large scale. It had, however, been adopted with considerable success in workhouses and institutions where a proper supervision was practicable, and where rules could be maintained for their proper use.

The commode is similar in form to that in use for sick rooms, but in lieu of a pan of earthenware, has a bucket of galvanized iron below the seat into which the excreta falls. A funnel-shaped box behind the seat contains dried earth, a pound and a half of which is thrown into the pail by the action of a plug similar to that in use in waterclosets, which covers the excrement and absorbs all the moisture. It is necessary to raise the plug previous to using the seat for the first time in order that the excrement may fall into dry earth instead of the pail itself.

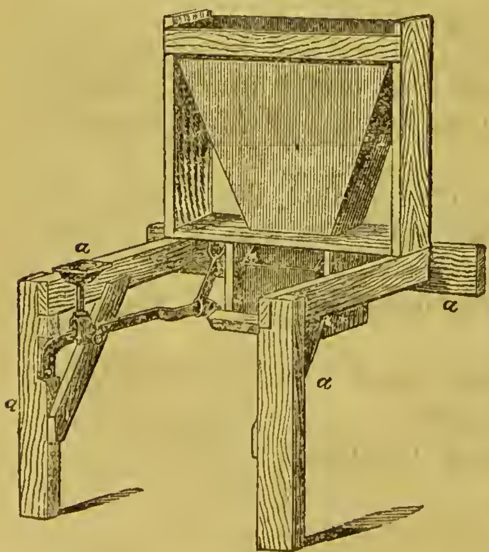


The chief feature in the apparatus is the mode of supplying the earth and discharging the proper quantity by a hopper.

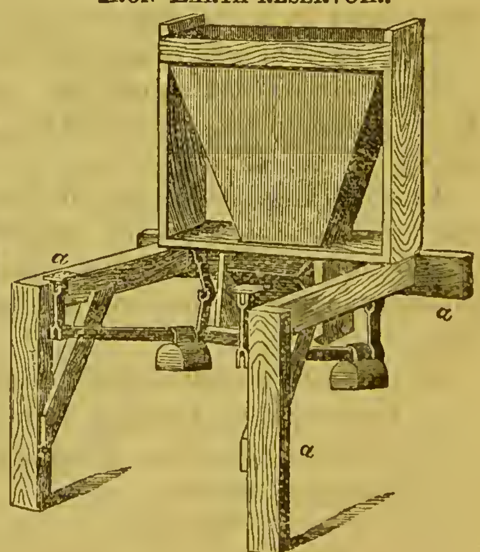
It acts remarkably well, throwing a broad shower of earth completely covering the surface of bottom of the bucket containing the refuse below.

The drawing given in the company's prospectus as below does not show this detail very clearly, and the above has been drawn

Pull-up Apparatus, with Iron Earth-reservoir.



Self-acting apparatus, with Iron Earth-reservoir.



without any particular accuracy, and to no scale, but will probably be of some assistance in understanding the arrangement.

The iron earth reservoirs have a slight play, so that the jerk of the plug may bring down the earth.

The prospectus provides that there may be a cesspit under the seat if desired instead of the bucket. The earth may be used twice or even six times over, provided sufficient time is given it to dry thoroughly.

I have heard country builders decry this system for use in houses, the reason assigned being that there is so much difficulty in getting the people to keep them in proper working order. They either use them without the earth (!) or earth that is not dry!!

It appears to have answered perfectly at Wimbledon in 1868 at the Volunteer camp. The minimum value of the manure is calculated at 3*l.* per ton.

I have inspected the privies and urinals fitted up at Wimbledon this year, and can testify to the total absence of effluvia of any sort arising from excrementitious matter or urine.

Mr. Stanford in the Chemical News, June 18th, 1869, shows that seaweed charcoal a quarter the weight of the earth will act as a good absorbent, and it is porous and cheap.

The weight of *earth* required is three and a half times the excreta, thus little more than an *equal* weight of *seaweed charcoal* will effect the same result.

When the mixed excreta and charcoal are removed it soon dries, can be stored for any length of time, and used again several times.

When convenient it is reburnt in an apparatus which admits of collecting the ammonia and other products condensed. The whole of the ammonia is thus collected, whilst phosphoric acid, potash, and mineral matters accumulate in the charcoal, together with the carbon from the organic constituents of the excreta.

The weight of the charcoal is increased about five per cent. with each using, and if dried and reused five times about 25 per cent. with each burning. With this constant addition the char does not require replacing with fresh material, so that its cost is only a primary outlay, the ultimate result being that the excreta is deodorized by a charcoal derived from itself.

The charcoal will absorb at least an equal weight, even of urine.

Mr. Stanford estimates the voiding of each individual daily:—If wet, fœces 4 oz., water 40 oz., total 44 oz.; if dried, fœces 1 oz., water 1·7 oz., total 2·7 oz.

In distilling 100 tons of the dry product from the mixed excreta, he estimates that he would obtain 72 tons of sulphate of ammonia, and 57 tons of a charcoal containing 10 per cent. of phosphoric acid in its most available form for manure, and six per cent. of potash.

Mr. Stanford sums up the advantages of this system that:—

There is total freedom from odour.

Certain prevention of spread of infection.

Saving of water.

Saving of expense.

By this process alone can the whole of the valuable material be recovered for our lands.

One cwt. of charcoal per month will suffice for a family of six persons daily using the commode. The whole may be allowed to fall through a 12″ pipe to a cesspit below the house.

A cess*pool* is a serious thing he considers, but he knows of no evil in a cess*pit.*

Romsey.—Taylor's System.*

Romsey, in Hampshire, a small town of 6,000 inhabitants, has had the benefit of a trial of Dr. Taylor's dry commodes, a great many of which have been in operation for some years. The following is a description given by the doctor himself of these contrivances, which are probably the nearest approach to completeness yet attained in a practical point of view.

The objection to the great amount of carriage of earth necessitated by Moule's system is almost entirely obviated.

These commodes are intended to supersede, waterclosets and those barbarous abominations, cesspits ; to very much lessen the defilement of well water and the pollution of rivers, and to prevent the poisoning of the atmosphere by putrid effluvia; to limit also the formation of maggots, and consequently to lessen the plague of flies ; and last, not least, to secure a return to the earth of those valuable food elements which agriculture is constantly demanding and exhausting.

The objects of the apparatus are, whilst the person is sitting there, to separate the liquid refuse from the solid ; to sprinkle upon the remaining deposit and on the soiled sides of the pan a small but sufficient quantity of a very cheap and universally plentiful, absorbent, deodorising, and disinfecting powder. When the lid of the seat is put down, levers are acted upon, which cause the floor of the privy pan to move away, and the residuum is cleanly scraped off, to fall on to a revolving table below. This table is moved a few inches each time the lid is raised, so that every deposit is separated from the next. By this means no massing of the solid matter is allowed, and the table being well ventilated the deposits are dried without smell and without offence into a guano loaded with phosphates and potential ammonia, selling readily at from 8*l.* to 11*l.* per ton. After the table has made a complete revolution the dried solid matters are pushed off by a scraper, acted on by the same levers, into a drawer or box placed under the edge of the table. The whole apparatus is made so strong and simple that it is not in the least liable to get out of order, and is calculated to last for many years. No attention is required more than to remove the accumulation and to supply the deodorising powder, and this need not be required oftener than about once a month. Great advantages may be gained in space when several closets are fitted up together.

The " absorbent, deodorising, and disinfecting powders " are—

1. Sifted refuse ashes. These, if used in sufficient quantity to absorb all the fœtid moisture, act very efficiently.
2. Sifted refuse ashes acidulated with sulphuric acid. About one pennyworth of acid to half a bushel of ashes. This neutralises the ammoniacal odours of the urine, and deodorises and absorbs all the fœtid moisture.
3. Sifted refuse ashes acidulated with sulphuric acid, and one pennyworth of carbolic acid to half a bushel of ashes. This not only

* The date of Dr. Taylor's first patent for drying and deodorising human excreta was 1857 ; the date of Moule and Bannehr's patent was 1860.

deodorises and absorbs all the fœtid moisture, but it disinfects all emanations of zymotic diseases.

4. Sifted refuse ashes acidulated with sulphuric acid, with the addition of carbolic acid, and a sufficient quantity of superphosphate of lime, to make the value of the resulting British guano greater far than that of the best Peruvian guano, but at a much less cost.

The liquid refuse * is made to run into any convenient drain, or to sink into the surface of the ground. From the nature of the urine any storage of it is unprofitable ; but if fresh, and separated from fœculent matter, there is no objection to its sinking into the earth's surface or to its running away into rivers. Fishes and water plants require and consume a certain amount of animal matter, and it is generally thought that river water can oxidise and make innocuous five per cent. of sewage matter.

In a pamphlet the doctor writes that "the dried excrement is " an excellent fuel, burning with a bright lambent flame. Heated " in a retort it produces a pure olefiant gas, having a larger pro- " portion of hydrogen than coal gas. A mixture with coal gas " would improve its combustion, as the smoke would be entirely " consumed. The coke left in the retort would consist of animal " and vegetable charcoal, and may be used as a valuable deodo- " riser in the closets. In fact the most complete deodoriser is the " charcoal from the excrement itself."

He informs us also that hydatids of different sorts, chiefly tapeworms, are mainly due to the consuming by individuals of diseased pork or any other animal which may have taken into the stomach the larvæ of tapeworms, &c., generated in the excrement of dogs or human beings.

Sheep will get them from the excrement of dogs deposited on the grass they may eat. These larvæ will develope in the brain, and give sheep the staggers.

Under-cooked meat is therefore to be avoided, and it will be seen how carefully excrement of any sort should be guarded from cows and other animals, and not allowed to lie about exposed.

As regards the commodes, I can say that they are perfectly unobjectionable with respect to the smell. I have seen them in operation when they were not very well ventilated, but perceived nothing offensive, and I may mention that Dr. Hewlett, the sanitary medical officer for Bombay, was with me when we inspected some in use at Romsey, I believe he had recommended their trial in Bombay.

The quick drying of the excrement completely arrests the putrefaction, if any exists, so that what sulphureted and phosphuretted hydrogen there may be is only what escapes from the intestines.

It is found that the commodes are absolutely smell-less with an absorbent powder acidulated with cheap sulphuric acid (about 1*d.* per lb.), and with a small quantity of carbolic acid will disin-

* In the provision for the separation of the liquid and the pouring of the contents of chamber utensils and slops into this apparatus, Taylor's system presents a marked advantage over Moule's, which requires the rigorous exclusion of as much urine as possible, and prohibits the emptying of slops altogether.

fect any zymotic disease that may be present, such as cholera, typhus, &c.

Dr. Taylor is about to use sulphuric acid absorbed by bone dust, for a deodorising purpose, which by adding superphosphate of lime to the guano will raise its value four pounds sterling per ton.

The absorption of the fœtid mixture by the dry powder, which may be ashes, or gypsum, any dry earth, or burnt clay, or saw-dust, or bone dust, in fact any absorbent material acidulated with cheap sulphuric acid, completely prevents fœcal and ammoniacal odours.

The arrangements of the company at Romsey for the management of their commodes are to collect from time to time the dry guano from the boxes, into which it falls from the drying tables, free of cost to the houses, dry it, if found needful in any portion of the later deposits, in a shed erected for the purpose, by simple exposure on shelves, and when thoroughly hard grind in an ordinary hand mill. It is then thrown into sacks and sold to the farmers, and finds a ready sale.

There is no doubt but that these commodes could be successfully worked on a larger scale, and that the best method would be by a company or contractor willing to relieve the houses of all trouble in taking away the guano, or keeping the commodes in working order. And it is tolerably certain that a good profit will result.

The rats must be kept carefully out, or they will relieve us of all further trouble in taking away the dried guano.

Dr. Taylor gives two interesting results of the analysis of excrement and that of the guano.

Excrement in consistent mass yielded to Berzelius.

Water	73·3
Solids	26·7
	100·0

The solid part.

Contained bile	0·9
Albumen	0·9
Salts	1·2
Extractive matters	2·7
Insoluble residue of food	7·
Mucus, fat, &c.	14·
	26·7

Dr. Herepath's analysis of Taylor's British guano.

Moisture	16·80
Organic matter containing potential ammonia	72·40
Phosphate of lime	6·50
Soluble salt, sulphate of potash, soda, salt	3·8
Sulphate of lime	0·40
	99·98

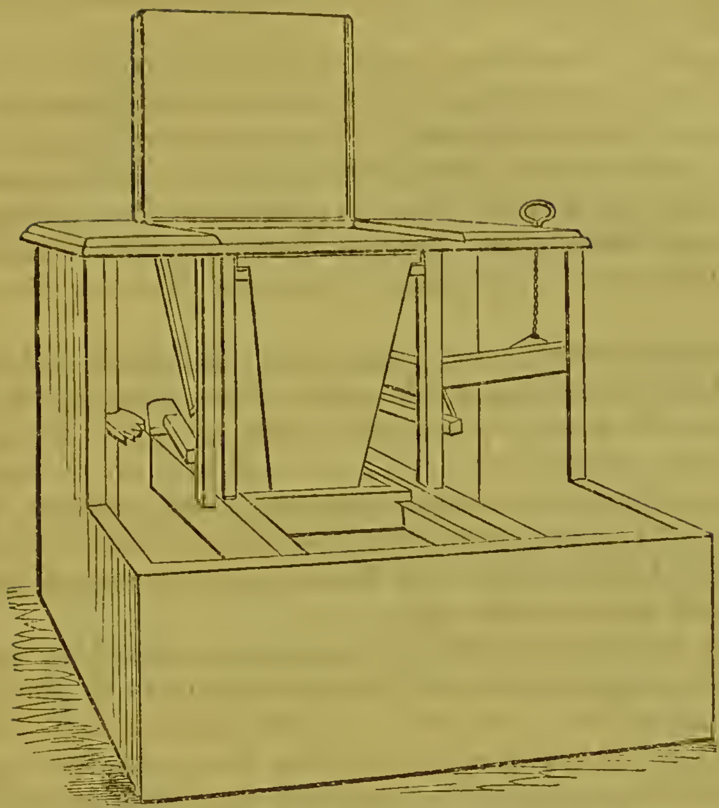
Available manure 83·20, beneficial to both cereals and green crops.

Enderlin deduced the following from ash of excrement:—

Common salt	1·3
Phosphate of soda	2·6
Phosphate of lime and magnesia	80·3
Phosphate of iron	2·10
Phosphate of lime	4·5
Silica	7·9
	98·0

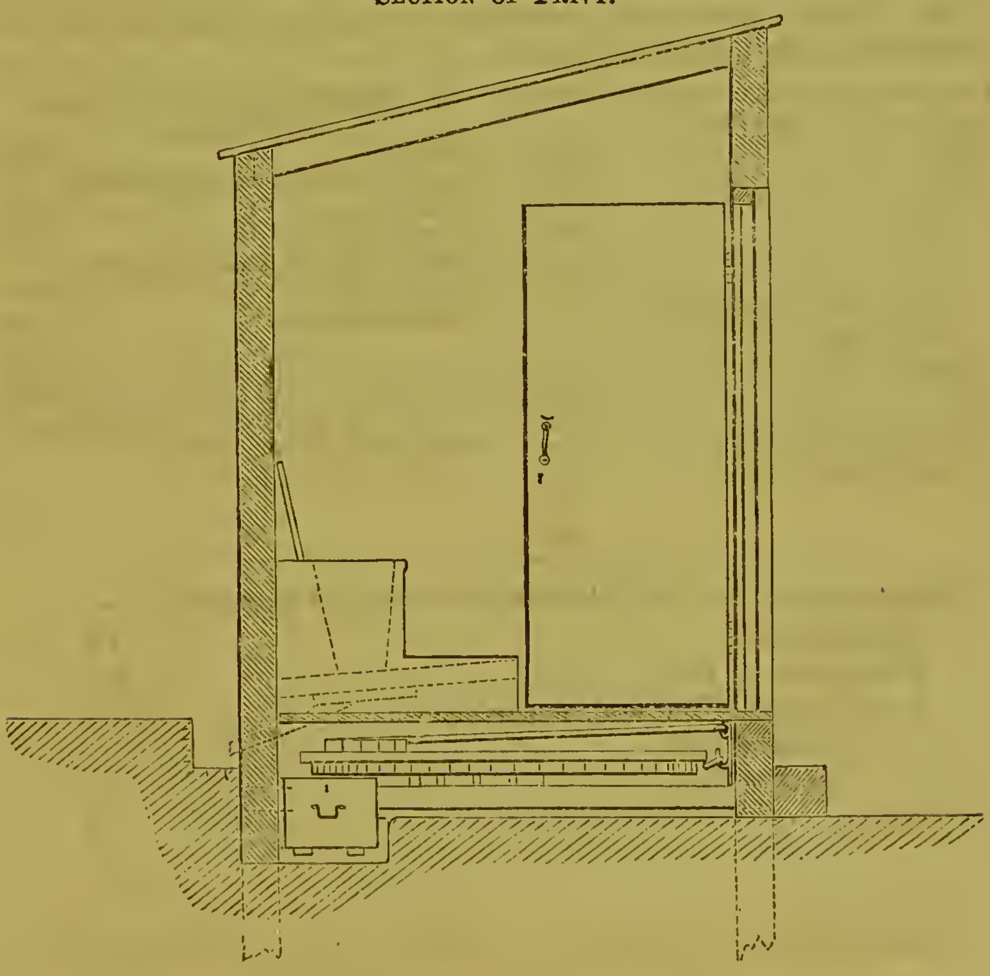
Bones contain 55 per cent. of phosphate of lime and magnesia.

DIAGRAM OF SEAT.



(The floor is removed to show the mechanism.)

SECTION OF PRIVY.



Some special arrangements for keeping out flies and rats seems likely to be required in India, by gauze, gratings, &c., and it is probable that the buildings could with advantage in this case, as in many others, be designed so as to have the whole of the lower compartment above ground, so that ventilation may be more effectual. Moreover a flue or shaft might be constructed to take off the light gases from below up above the roof, the floor being made quite airtight at the same time, which would effect a minimum of smell in the privy.

Before leaving this part of the subject it will be well to refer to a method of sewage removal by atmospheric pressure, described in the *Chemical News* of June 4th, 1869, as Capt. Tiernier's, by Ed. C. C. Stanford.

I am not aware of its ever having been tried anywhere, but there is considerable orignality in the idea.

The excreta falls from the closets at once to the basement of the building, where it remains in the bend of an iron pipe 5″ diameter connecting the house with a central reservoir under the public street containing 20 cubic feet, allowing one cubic foot to every 36 individuals.

The mode of emptying these receivers is by a "locomotive engine and pneumatic tender," which is drawn by one horse. The engine works a powerful air pump, which is placed in connexion with the reservoir, and the vacuum of about 10lbs. to the square inch, or 20 inches barometer pressure, which is formed in the receiver, in the first instance causes the house pipes to deliver into the receiver directly the valves are opened, and in the second instance causes the soil to rise up the pipe from the receiver into the exhausted tender, when the connexion is made by the requisite pipe. The foul gas from the air pump is blown into the engine furnace.

The contents of the tender is emptied into barrels of five cubic feet capacity, to be sold in that state for manure.

The difficulty of course would be to dispose of the manure regularly, or provide for its keeping when not actually in demand.

CHAPTER III.

MISCELLANEOUS.

IRRIGATION OF CROPS.

Thomas Carghill, C.E., gives a little information on the subject of grass, cereal, and root crops, showing the actual results down to date 1869.

Name of place.	No. of cuttings per annum.	No. of tons to acre.	Highest price.	Average price per acre.
			£	£
Edinburgh - -	5	47	40	27
Norwood - -	5	60	34	25
Croydon - -	4	35	35	30
Barking - -	6–8	61	76	40

He says, " The comparative impunity with which grass crops will " receive almost any amount of sewage, and the reckless and un- " scientific manner in which it may be applied to them, have no " doubt contributed to causing them to be hitherto the principal " crops upon which to experiment."

In applying too large doses of sewage to cereal and root crops a great deal of care is required. Too large a quantity will cause the crops to run to straw, and the ear will suffer. (This is, I believe, the case also with irrigation by pure water only.)

An experiment at Barking on the same land, with and without sewage, produced a crop of wheat 50 per cent. greater in the former than the latter case.

Mangold wurtzel has been grown at Chelmsford and Barking. The average return was 50 tons per acre, or double that on unsewaged land, although it had received 20 tons of cowhouse manure, with a quarter ton of guano, mixed with superphosphates and common salt.

Three dressings are all that is required for the growth.

A much larger quantity of sewage will be required for light than heavy soils and stiff clays. The writer estimates that the sewage of 100 persons will be required per acre to yield 40 tons of grass annually. Between 5,000 and 6,000 tons is the most profitable quantity to apply annually per acre, but at Edinburgh 8,000 is the usual allowance. One point is, however, certain—that after a given quantity has been applied the application of more is not attended with proportionate increase of results.

The following crops were grown with either two or three floodings of sewage :—

Per acre.				
Wheat,	5½ quarters,	selling at	60*s*.	per quarter.
Oats,	8	,,	27*s*.	,,
Rye,	6	,,	40*s*.	,,

40 tons of mangold were grown to the acre.
25 ,, sugar beet ..

Red cabbage	realized	35*l*.	per acre.
Parsnips	,,	35*l*.	,,
Onions	,,	30*l*.	,,
Strawberries	,,	75*l*.	,,

It was found that the onions evinced a certain repugnance at being treated with sewage, but that this was overcome by judicious treatment.

The writer says: "This may be considered a proof that with "respect to the exact quantities of sewage, and the most suitable "times for application, we have everything to learn."

Of all methods of distribution of sewage that by *open* channels is the only one that succeeds properly.

It is distributed on this footing by three ways: —

1. The catch-water plans, for steep or hilly ground.
2. Pane and gutter ,, for gentle slope (*see* Croydon).
3. Ridge and furrow ,, for level ground (*see* Barking).

Cost per acre of preparing the ground for No. 1 is stated to be 2*l*. per acre.

The cost of No. 2 at Edinburgh was 12*l*. 10*s*. per acre, and maintaining the fields in working order cost 3*l*. per acre.

The cost of No. 3, 5*l*. to 20*l*. per acre, but no data available.

Green crops are the only ones which can stand and in fact benefit by *excessive doses* of sewage *at all times.*

Other crops cannot be stimulated or forced to the same extent, and are only injured by *such treatment.*

Estimating the price of a pint of milk at 1*d*., the following shows an interesting result of sewage application for the necessary grass to produce it:—

Quantity of sewage (tons) per acre.	Value of land as milk. £	s.	d.
0	15	0	0
3,000	25	7	0
6,000	33	6	10
9,000	36	1	4

Note that the increase of sewage from 6,000 to 9,000 tons does not yield half the additional profit that an increase from 3,000 to 6,000 does. Thus the maximum limit will be apparent beyond which to irrigate will produce loss instead of profit.

Rye grass should be cut just before it begins to form seed. It should be ploughed up every second year, a root crop taken out of the ground, and then it may be resown.

After applying the sewage in large doses for two or three years on grass lands, intermediate grain crops may be grown in great perfection from the manure or residue of the sewage constituents

left in the land. Clayey soils in particular possess a remarkable power of retaining or storing up food for plants.

The Local Management Act.

This Act and the several amendments thereto are published in a concise form by Weale & Co.

The Act for the better Local Management of the Metropolis, 14 August 1855, is the one referred to, and provides for the local management of the metropolis as regards paving, cleansing, lighting, and improving generally, and especially in the matter of the *sewerage* and *drainage.*

The amendment of 29 July 1856 relates to minor matters, chiefly in regard to rating and the right to vote at elections.

The amendment of 2d August 1858 relates almost entirely to the great works for sewering the metropolis.

The last amended Act of 1 August 1861 provides for the mode in which the Local Management Act may be adopted wholly or in part by any town.

The Act provides for the management of all matters connected with the public health by a local board in every town that may adopt the Act.

Directs the formation of parishes into districts, and the constitution of the boards.

Defines the duties and powers of the boards, including the maintenance and repair, and also renewal from time to time or construction of additional sewers in their districts, provided the plans of new works are approved by the government. (In the metropolis the *main sewers* are under the Board of Works, entirely distinct from the district sewers, which are smaller ramifications thereof.)

Where any person is liable by law to maintain or do any work to any sewers which the board find it necessary to alter or improve, the expense is to be shared by the person and the parish.

The district boards are liable to see that proper traps are provided for preventing stinks from street gullies, and for ventilation of sewers.

The boards may compel owners of property to construct drains into the common sewers at their own expense, provided the sewer be not at a greater distance than 100 ft. from the property. The work is subject to inspection of the local authority, and has to be executed with all the necessary apparatus of traps, sinks, &c., to be effective and complete. After a 28 days' notice for such work to be done by any owner of property the board may proceed to do the work, and recover the cost from the owner if he neglect the requisition.

No new house is to be erected without drains approved by the board's inspector, and that approval is to be obtained before beginning to dig the foundations.

Any person is entitled to lay a drain to a sewer, provided it is authorized by the board; but if anyone should do so without permission, or alter the size or specification, he is liable to a penalty of 50*l.*

The board when laying any works underground are entitled to lay drains at the time, should any be found wanting to private property contiguous to the opened ground, and recover the cost from the owners.

The board can and should undertake the *construction* of the house drains if requested, of course at the expense of the occupiers.

A penalty of 20*l.* can be enforced for the erection of any new house, or rebuilding an old one, without a proper watercloset or privy with ashpit furnished with proper doors and coverings.

The board have power to order such closets or privies to be supplied where none exist, or supply and charge them on the occupiers if not attended to.

The inspector has power to proceed to inspect any drains, &c., after 24 hours' notice in writing.

Section LXXXIII. of the Act provides for the protection of the works of drains, cesspools, traps, &c., on any property, from damage, alteration, or stopping up, under a penalty of 10*l.*, and if the person do not proceed within 14 days to reinstate the works in their former position the board may do the same and recover the expense.

Where no fault exists on the part of the owners of property, they having fully acted up to the regulations, the expense of any reinstating will fall on the board.

Owners of property are to maintain the drains and other appliances in proper working order, or the works will be done by the board and the expense recovered.

Scavengers are appointed to remove solid refuse and cleanse sewers or cesspits, under penalty for neglect of 5*l.* and anyone obstructing such removal of refuse may be fined a like sum.

Removal of refuse of trade is to be paid for by the owners.

The overseers of the poor-rate, are to levy the rate for sewers, being so much in the pound of annual rental of the house. *Land* is rated at one-quarter the annual value.

The rates can be recovered by distraint, through the overseers, if necessary.

General powers to Metropolitan and district boards to borrow money on mortgage are provided in this Act, and may be effected on the security of the rates.

A sinking fund is to be formed for paying off such mortgages from a sum of not less than 2*l.* per centum of the amount of principal moneys secured thereby. Lots to be drawn to determine the particular mortgage to be paid off.

Auditor of accounts is appointed by the Secretary of State, but paid by the board (Metropolitan).

District auditors are elected locally and attend the head office nce a year for general audit.

Provision for Protection of the Property of the Boards, &c.

Buildings are not to be erected over sewers without consent of the board,

Five pounds penalty for sweeping dirt, soil, rubbish, &c., into a drain.

Repayment of costs of any works from private persons may be spread over 20 years, interest at 5*l.* per cent. being charged.

Penalties inflicted under the Act to be sued for within three months of commission of the offence.

Power to extend the Act to adjoining parishes containing not less than 750 ratepayers is provided for.

The Amended Act of August 1858

refers to the metropolitan main sewerage. Provides for taking up the land, and for permission to construct any works, for raising a sum of 3,000,000*l.* by bonds or debentures under the guarantee of the Treasury for repayment.

Provides that a government engineer shall be appointed to inspect the works and accounts at any time. The Metropolitan Board to levy a rate of 3*d.* in the pound, to be called the "metropolitan main drainage rate."

The board are to execute the works without creating a nuisance.

On complaint of nuisance committed in execution of works, the Secretary of State may order prosecution with a view to the abatement or removal.

The last Amended Act, 1st August 1861.

Every local authority invested with the power of town government may adopt any part of the "Local Government Act."

Local boards may exercise powers in reference to disposal of drainage out of their own immediate district, provided they make all due compensations, and do not use any outfall drain or sewer for the purpose of conveying sewage or filthy water into any natural watercourse or stream, until such be freed from all excrementitious or other foul or noxious matters, such as would affect or deteriorate the purity and quality of the water in such stream or watercourse.

Three months' notice to be given to all concerned by advertisement, and a plan to be deposited for public inspection before any extension of a main drain is thus made, and if any objection be raised the work cannot proceed without the sanction of the Secretary of State, when an inspector will be sent to report.

The sanction of the Secretary of State is required for the borrowing of money for works.

The *amendment* of 7 *August* 1862 provides, amongst other things, that district boards submit plans of new sewers to the Metropolitan Board for approval.

Three days' notice shall be given previous to the connexion of any sewer or drain with a *main* sewer, which junction is to be made to the satisfaction of the board.

Seven days' notice before drains can be branched into main sewers is required.

Section LXVII. provides that district boards may compel the

owner of a house, in which there is no sufficient water supply, to do what is necessary to obtain such supply, provided it can be furnished to such house at a rate[4] not exceeding 3*d.* per week. The board may also order the supply to be increased if necessary, so as to afford 30 gallons per head in the house, or in default proceed against the house for "overcrowding."

Any person damaging or disarranging a sewer in any way is liable to fine of 20*l.* and the expense of reinstating.

Any person laying the foundation of a new building without having first given notice in writing, with a view to the inspection by the drainage department, is liable to fine 5*l.* and a continuing penalty of 2*l.* per diem during which he shall omit to give the notice.

"The Health of Towns Act," 2d August 1858.

This Act amends a former one of 1848, called the "Public Health Act."

The Act defines the nature and constitution of local boards and their proceedings, and renders compulsory the removal of nuisances of every sort inflicted on parishes by any adjoining one.

Drinking Water Supply.

The water supply of towns is, of course, of immense importance to the welfare of the inhabitants.

It is impossible in the present instance to enter at any length into the question, though it is intimately mixed up with that of drainage, but mention may be made of a few things of general interest.

Water consists of the combination of two gases, oxygen and hydrogen; one measure of the former to two of the latter. It, however, has a great power of attracting impurities. If a can of water be stood in a room recently painted it will smell of the paint; if it be near a privy or cesspool it rapidly attracts the noxious gases to itself.

Sewers and drains traversing ground that supplies wells are sure to contaminate the water, unless constructed in the most efficient manner.

The chief supplies of water are probably from the rivers, and if they are not polluted by the direct discharge into them of foul matter on the banks, or from sewers of any kind in the neighbourhood, they are probably as pure a source as can be desired.

Rivers are known to have a remarkable power of purifying a certain amount of impurity in the shape of organic matter, even so much as five per cent. of sewage within a distance of a few miles.

Water percolating through the earth into rivulets and afterwards forming streams has been purified generally by the impurities, chiefly those obtained from decomposing organic matter, being eagerly taken up by the soil to form the food of plants.

Thus many of the towns of England are supplied from the

rivers, directly or indirectly. Some are supplied by wells sunk into the deep chalk formations, and such are Croydon, Worthing, &c.; others are supplied from artificial lakes.

The waters that are considered to be most prejudicial may be put down as those containing decomposing *organic* matter. It is not shown that the admixture of *mineral* matter, though it represents so much impurity, is prejudicial to health. Living forms of life are to be found in waters that have been stagnant; these are to be filtered out before the water can be drunk with safety.

Mineral matters, especially lime, produce hardness in the water. This is objectionable for cooking purposes, for washing, &c., and animals soon show their preference for the soft water for drinking.

Many means have been tried for rendering water fit for drinking by means of filtration, &c., the medium being sand, sponge, charcoal, &c.

It is probable that animal charcoal produced from burnt bones, &c., is the best of all. The London and General Water Purifying Company show in their pamphlet how this filtration can be best effected by a charcoal filter, to be placed in the cistern, through which the water will rise, and, passing through the charcoal, be discharged through the syphon pipe.

Directions for Cleaning the Cistern Filter of the London and General Water Purifying Company (Limited).

Introductory Remarks.—The water being slightly discoloured by suspended matter must not be regarded as an indication of the filter requiring cleansing; it is only an indication that the water passes too quickly through the filter, and which may be checked by screwing down the regulating piece as described in the directions for fixing the filter, on the previous page. The indications of the filter requiring cleansing from the accumulation of clayey or suspended matter in the filter will be shown by the speed of the water passing through the filter gradually decreasing of itself until it becomes inconvenient.

If the filter becomes overcharged with organic matter, it may be detected by a few drops of a weak solution of permanganate of potash being added to the water. The solution is as follows:—One grain of permanganate of potash to 1 oz. of pure distilled water, and which solution may be had of the company in one shilling bottles ready for use. The result will be most quickly seen by adding the smallest quantity of the permanganate that will suffice to give the filtered water a perceptible tinge of colour. If after standing several hours the colour is unchanged, it may be safely assumed that the filter is doing its work properly; but if in the course of a short time the bright tinge changes to a dull yellow, the filter may be assumed to be overcharged with organic matter. In making this experiment it is desirable that the water under treatment should not be exposed to the external air, as the permanganate readily absorbs any noxious gases with which it may come in contact, and may influence the result. The fact of the decrease in speed of the water would suggest the application of the test.

General Directions.—When the filter ceases to act satisfactorily from either of the above causes, it may be detached from the pipe by unscrewing the union which is immediately above the cap of the filter, the filter taken out of the cistern, and the charcoal removed and cleaned or replaced by new. To effect this the cap of the filter must be removed

by knocking the claws of the iron holding the cap down, round on the graduated edge to the thinnest part of it, when the openings in the edge will allow the iron being taken off and the cap then removed from the filter. The strainer must then be removed, after which the charcoal must be shaken out. Being immersed in water will very much facilitate emptying it, as it is very tightly packed.

To cleanse the charcoal it should be left to soak in luke-warm water for a short time, which will free its surface of organic matter, and afterwards well washed in clean water. The water in which the charcoal is washed will always be black, and affords no guide to the charcoal being clean. After washing, the charcoal must be dried and sifted into two portions—No. 1, the very coarse; No. 2, the remainder. It is essential that it should be quite dry, both for sifting it and refilling the filter.

To refill the Filter.—First put in No. 1 (the very coarse charcoal) to the depth of 1 or $1\frac{1}{2}$ ins.; then the body of the charcoal, No. 2, may be put in, the filter being kept in constant motion by raising it a little on one side and allowing it to receive a slight downward jerk on whatever it may be standing, the filter being turned occasionally to ensure the motion being equally distributed. By this means a much larger body of charcoal may be got in, for after being apparently full many times it will be found still capable of holding more. The last 1 or 2 inches should be the remainder of No. 1 charcoal. The strainer must be then replaced by agitating the filter as before described, and pressing it upon the charcoal, which will cause the charcoal to gather well round the strainer. The cap and rubber washer must be fixed as before, and the iron claw knocked round carefully with a mallet to its original position. Replace it then in the cistern in its original position, and after being secured by the union to the pipe it is ready for use.

Instructions for Fixing the Syphon Cistern-Filters.

Before placing the filter clean the cistern thoroughly. Place the filter inside the cistern, water-butt, or other water-holder, resting on the floor as shewn in the accompanying diagram. If the water deposits very much sediment on the bottom of the cistern, it will be advisable to raise the filter 2 or 3 inches on bricks, so that the deposit may not interfere with the action of the filter. In fixing Nos. 1 and 2 filters, the pipe, which acts as a syphon, is usually carried over the top, and down outside the cistern to any convenient point (*at a lower level than the bottom of the cistern*), where a tap is fixed as shown in the diagram; but they can also be fixed as No. 3 and larger sizes, when like them they are self-acting. As the correct action of the filter depends upon the exclusion of air, care must be taken that the union joints and the cap of the filter are quite air-tight. This being right, the air is drawn from the pipe by opening the tap and sucking the air out, when the water imme-

Nos. 1 and 2.

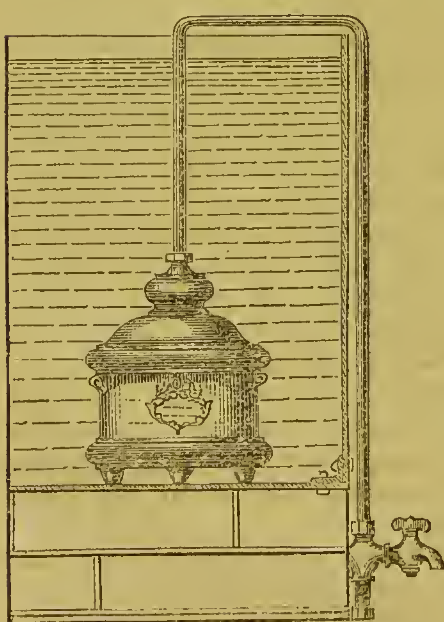


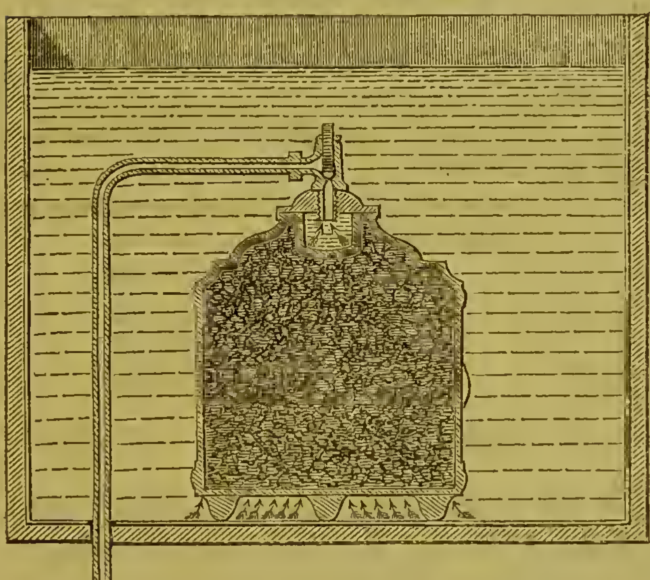
Fig. 9.

diately fills the vacuum thereby created, and the filter is at once put in action, requiring no further attention, unless the cistern may have been emptied of water, when it must again be set in action by drawing the air from the pipe. It is not absolutely necessary that the filter should be covered with water, for so long as the lower edge is covered it will continue to act. It should be remembered that Nos. 1 and 2 are chiefly adapted for supplying drinking water.

In fixing No. 3 and larger filters, it is usual to connect the filter direct with the pipe supplying the water for all domestic purposes, as shown in the accompanying diagram. If when the cistern is full the water covers the filter, it will be entirely self-acting ; and in case of the cistern having been emptied, the filter will recommence its action as soon as it is again covered with water, without requiring any attention. If from any cause the filter should not be covered by water when the cistern is filled, it may be set in action by drawing the air from the pipe. Size No. 3 is constructed to give 2 gallons of water per minute, but the largest size should be substituted for it if more than 2 taps are connected with the pipe to which it is attached. The No. 4 size will be found sufficient for the requirements of a large household. Care must also be taken that the union joints and cap of the filter are quite air-tight.

No. 3 and larger sizes.

*Fig. 9.



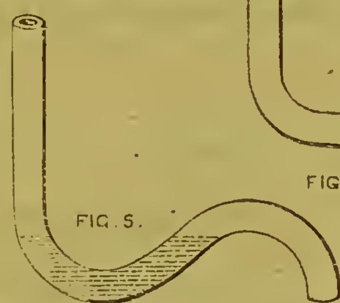


FIG. 5.

FIG. 6.

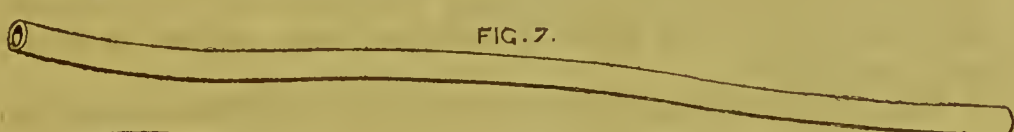


FIG. 7.

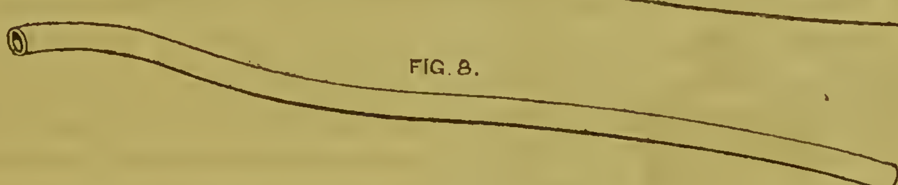


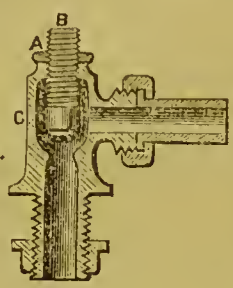
FIG. 8.

In the arrangement of pipes care is required that *no bend upwards* is made in them, for if so, in case of the cistern becoming emptied, air would get into the upper part of the pipe, whilst water is lodged in the bend, and unless there is considerable pressure of water above, a difficulty would be experienced in dislodging the air. When a bend occurs, as in Fig. 5, an air pipe inserted in the pipe leading from the filter and carried below the bottom of the filter, will obviate all difficulty ; but so long as there is any fall in the pipe, however slight—or even if it be on a level

only—this difficulty does not occur. Figure 5 shows a case in which there is a possibility of failure from a lodgment of water in the pipes if there be only a shallow depth of water in the cistern; but if the pipes be arranged without any upward bend, as in figures 6, 7, and 8, there is no possibility of failure from this cause.

When the water is very impure, or filtration too rapid from great fall pressure, it is necessary to diminish the stream of water passing from the filter by means of the check piece, or regulating screw, shown at Fig. 9. By loosening the binding screw with a nurled edge A, the regulating screw B may be screwed down, which will lessen the water way at C to any desired extent. The binding screw should then again be tightened to prevent shifting of the regulating screw, and to prevent leakage. Once properly adjusted, it will require no further attention. Rain water, or water much coloured with clay, generally requires a slower process of filtration than other kinds of water.

*Fig. 9.



The water may at first be slightly clouded, from the action of the charcoal upon the lime; but this will quickly disappear, and the water become as clear as crystal.

These principles are evidently capable of being carried out in a more primitive fashion in India.

A comparative analysis of the water supplied by the London water companies is quoted as below:—

	Grains per gallon of *organic* matter.	*Inorganic* grains per gallon.
1851* - - -	2·73	19·53
1856 - - -	1·24	20·93
1863 - - -	2·58	22·50
Croydon (*see* Croydon)	1·09	20·02

Water holds impurities in mechanical suspension and also in solution.

It seems to be very difficult to maintain large filters in an effective state at the head of a supply; much, however, could be effected by purifying the water in the houses in which it is to be consumed, and some such system as that of cistern filters appears to be the most convenient.

The methods of testing water are various for different impurities.

Organic Matter.—Evaporate a small quantity and burn the residue, if any; when smoke of a peculiar colour will appear if organic matter exists; or add a few drops of permanganate of potash; the colour produced will be permanent if free from organic matter, but will disappear if not.

Ammonia.—Highly dilute chloride of zinc.

Air in Water.—Raise temperature, when bubbles will appear on the sides of the vessel.

Carbonic Acid.—Add lime water; carbonate of lime is formed.

* Cholera and diarrhœa year.

Lead.—Bichromate of potash or iodide of potassium causes a precipitate of the lead. The water may be concentrated to one-eighth part by boiling first.

Chlorine or Chlorides are detected by nitrate of silver, which occasions a white precipitate insoluble in nitric acid, but soluble in ammonia in water containing chlorine or chloride.

Magnesia.—Phosphate of ammonia and soda added to water that has been boiled and precipitated by oxalic acid produces a precipitate in a few hours if the water contains magnesia.

Bicarbonate of Lime.—Lime water produces a precipitate.

To soften water containing lime it is treated with lime water ! ! The explanation is this:—

Blow through a tube into a glass full of lime water (*i.e.* containing a perfectly clear solution of lime), a precipitate of carbonate of lime (or chalk) will result; continue blowing, and the precipitate will for the most part dissolve again.

The carbonic acid of the breath makes the lime at first into chalk. Now this chalk is quite insoluble in water, but is soluble in water impregnated with carbonic acid.

Now when lime water is added to water containing carbonate of lime under such circumstances, the carbonic acid uniting with it forms chalk, and as the free acid no longer exists in the water the chalk before held in solution also falls down.

CONCLUDING REMARKS, CHIEFLY WITH REFERENCE TO SEWAGE APPLICATION TO INDIAN TOWNS.

The application of any of the methods of sewage disposal described in the preceding pages to towns in India would differ from that in England, chiefly on account of the great heat of the climate.

Now as towns continue to exist in India, notwithstanding the heat is greater and the sanitary state of the streets and houses much worse, it is reasonable to suppose that any drawbacks experienced in England would not be likely to prove the system impracticable in India.

The habits of the people differ of course. Some modification of the European watercloset would be necessary, to suit the "water" instead of the "paper" process. It is probable that the only system of *dry* conservancy which could be most economically practised, having this in mind, would be that of Dr. Taylor, which admits of water or slops of any sort being thrown into the receptacle without interfering with the drying of the solid excreta.

Now with regard to the application of manure resulting from such processes to the land, it cannot be foretold in what favour it may be regarded by cultivators. I have noticed in parts of Gugerat heaps of village rubbish spread about over the fields, proving that in such neighbourhoods they are alive to the benefit of decaying matter, but I have often heard it stated that the black soil is so fertile that it never requires manure. Now, however fertile the land may be at present, there can be no doubt that sooner or later the fertility must be impaired, without a return to the soil of some of the properties constantly withdrawn from it being made.

Moreover, it may be regarded an open question whether if certain constituents were supplied to the soil in the way of manure, finer crops, such as cotton, might not be produced.

Thus any theory upholding the absence of necessity for returning decaying matter to mother earth is not likely to meet with favour in enlightened communities.

Mr. Hope in the Leamington Congress gives an able essay on the respective merits of the dry and wet systems of sewage disposal, and shows that the value of the fluid and solid excreta of one person is worth 10*s.* per annum on the average, and the lowest estimate gives 8*s.* 6*d.* (Lowe and Gibbs). Liebig's calculation of the weight of human excretions, fluid and solid, when reduced to powder by drying and pulverising would be 45 lbs. per one person, of which 10·3 lbs. would be phosphates. The weight of the fluid and solid excreta fresh is about 3½ lbs. per head, or liquid 3·35 lbs., solid 0·18 lbs. The proportionate value of the solid and

liquid excreta is given as 1*s.* 8¾*d.* to 10*s.* 3*d.*, or as 1 to 6. In the estimate the prices of the constituents are given at

Ammonia - -	56*l.*	per ton	Liquid.
Soluble phosphate	32*l.*	„	
Potash - -	31*l.*	„	
Organic matter -	1*l.*	„	
Insoluble phosphates	7*l.*	„	in solid excretions.

In irrigation the average amount in dry weather per head per annum ranges from 40 to 60 tons.

An average of 50 being taken, and an expenditure of 5,000 tons per acre for irrigation required, shows that the sewage of 100 persons may go to the acre for grass crops.

The value per ton of sewage thus expended is generally put down at 1*d.*

The value of earth which has *once* passed through Moule's closet is calculated at 1*l.* 0*s.* 6*d.* per ton.

The proceeds of Dr. Taylor's are calculated at between 7*l.* and 8*l.*, and both are sold at these prices.

It may at once be seen what a great advantage is to be obtained by farmers if they will adopt one or other of these systems for as many persons about their lands as they can induce to co-operate; and as the fluids would be retained by Moule's it might be adopted with profit where the carriage was not great; or in case this would be too formidable, Taylor's system supplies a remedy, though by it the fluids would have to be utilized either by irrigation or water carts. The system of returning everything to the land is, we are told, carried to perfection in Japan, where no other system of manuring obtains, and in China the same practice prevails, though it is attended with results unpleasant to the nose by reason of the rudeness of the system of application.

One thing is established, that to raise a crop on land not rich enough in the proper constituents in the soil, the proper manure to apply is the excrement or refuse of the particular crop formerly consumed. Thus, if manure from the pig, which has consumed husks of corn, be applied to wheat, a crop will be produced in which there will be an undue development of husk; whereas that from the human being or horse, which has consumed nothing but the flour will produce a corn heavy in the ear. Nothing shows more conclusively that for the food of man to grow properly, the best manure to use is the human excrement; again, horse stable manure is known to be the best for growing oats and grass.

Now, as it may be many years before systems of drainage will exist in many towns in India, dry conservancy should doubtless have a prominent place in our consideration.

It is usual for the excrement to be taken away on the heads of the scavengers in buckets in a putrefying state and hidden from sight at the nearest opportunity, whence it does not fail generally to send out sweet reminders of its hidden existence.

Let alone the demoralising effect produced on the part of

employers, and the effect on the men employed in such a calling, the system is full of danger to the communities.

It is astonishing that even in Europe, though, such an amount of modesty should exist that as long as each individual can get rid for the time of what he no longer requires in the most secret manner possible, he cares not who comes next after him to endure the disgust of his neglect.

It is certainly only a sham modesty that has not the least regard for other people, or in turn of course for himself.

It is impossible for any system of conservancy to act without the persons most interested seeing to the proper working themselves, and if we do not feel an interest in being clean really, what occasion have we for modesty such as ours.

The master of every house is morally responsible that the arrangements for the comfort of the inmates are looked to in this respect. The local authorities should be responsible that these do their duty, and the government should ascertain and lay down the best rules for their guidance.

For a complete state of things to exist, it seems as if society required educating ; a few false notions want to be expelled from the social code, and more *attention* concentrated on a subject of such immense importance, instead of *shame.*

For those that can afford to pay for the transport of dry earth, there is no doubt that Moule's system is complete in itself; and if the buckets were emptied daily and carted away the houses would be as clean and sweet, not to say free from danger of sickness, as could be desired.

Now to effect this arrangement requires combination of house-owners. An arrangement made with some contractor for the daily removal of the refuse would easily be effected. Such contractor would best be found from amongst the lower class (Bhungies) and sweepers, who would endeavour to find a means of disposal to cultivators. Till such a market is found for such manure, the local authorities should cultivate under their own auspices some land, with a view to show what the effect is likely to be, as has been done in the case of sewage irrigation by private individuals and companies in England.

This remark will apply equally to every system of sewage disposal, and equally to every system of reform, of whatever kind. Persons not capitalists living by the cultivation of the soil are not in a position to try experiments which *may* fail. It is the duty of those whom it has pleased the Almighty to favour with the command of capital to use such to the advantage of their fellow creatures. All persons living by *usury* may take this into consideration, that as they live by the produce of money, or the mere title to so much weight of silver, which neither eats nor drinks, nor costs them anything at all, *they* are the *real* idlers living on the work of other men's hands, unless they employ that wealth to some useful thing, which while it benefits them will prove a blessing to all as well.

Use your money then in procuring the advancement of some

branch of manufacture, or some great or small work that will directly return you a legitimate interest, instead of aiming at the realization of a fortune at a throw of a dic, which may or *must* involve some one in a loss to an equal amount.

The system of *usury* grinds down the working men, and keeps an empire in the dust which ought to rise to the equal of all nations.

That there is plenty of wealth amongst certain classes in India is obvious; that this wealth may be increased by being legitimately employed is certain. If those influential and excellent native gentlemen, of whom Bombay has shown herself to possess so many eminently qualified, would manifest their disapproval of every transaction partaking of the nature of gambling, and encourage the employment of capital in reproductive works direct, they would show themselves what I believe them to be, the best friends of suffering humanity. Bombay would rise to be the first city in the world, and with it the names of those gentlemen who had made such a great step would be foremost.

Were there any middle classes of *monied* men there would be no difficulty in getting contractors to do work of any description, but whereas there are only two classes, those with money who do nothing for it, and those without who do all the work, nothing can be done.

The only remedy is, advance the capital for contractors to work on until such time as they may have improved their circumstances through a general impulse to the labour market.

Should such a system start up, and I have tried its efficacy in the matter of government works, there will soon be no difficulty in getting anything done. Everyone will spend twice as much money as he did before, but he will be able to earn twice as much, and the whole community will be benefited. Those who are now influential amongst hundreds will be influential over thousands, perhaps millions, not only of such men as exist at the present moment, but well-to-do artizans and tradesmen, ready to give them their votes when they wish to be elected to any office of authority or emolument in return for former blessings conferred.

This subject, so enthralling a one, has led us somewhat away from the subject of drainage disposal, but it is somewhat mixed up with it in effect, for the towns cannot be drained that cannot pay for drainage, nor can they pay unless they are prosperous, nor can they be prosperous while there is *usury*. Then indirectly usury is at the root of death and disease, and when that comes, we find we have been making a fatal mistake, for our ill-gotten gains will not prolong our life one breath.

It is probable that there are many situations where Dr. Taylor's apparatus could be applied, but without a trial under proper supervision in the country, it would be superfluous to dilate on what might be done. It is worth while, however, to point out that till there may arise a demand for the manure it might be utilized to form illuminating gas, the ashes being disposed of for deodorizing, in the further use of the apparatus. It would be for

the gas company to ascertain how far it would be economical for them to use this material, or to make arrangements for collecting it.

Precipitation and Deodorization.

The populations of towns the sewage of which has been treated by deodorization and precipitation, have in most cases not been very large. The systems have been tried apparently in many places which have since adopted irrigation, probably because it was cheaper in their particular cases, or because from ineffective apparatus the deodorization and precipitation was not satisfactory.

The results of the treatment of sewage for the production of a profitable manure are very various. It is difficult to ascertain the actual value of the manure in some cases, for the companies who have undertaken the business naturally do not afford complete information on such a point. I am inclined to believe, however, that at the present time no large profits, if any at all, are being made in this department; nevertheless, there are not wanting many persons ready to undertake the deodorization of towns on one or other system. At Stroud the present company have had the works a long time, and it is presumed that they have received sufficient remuneration to enable them to carry on from the sale of the manures manufactured. Their agreement extended over 20 years, not half of which I believe have elapsed.

At Leamington the A.B.C. Company was prepared to undertake the sewage works for 20 years.

From communications I have had with some of the persons connected with these works, I understood that they were not prepared to deal with the sewage of such enormous populations as that of London, though I was told that it could be managed by dividing into several districts. The objection, I suppose, would be the magnitude of the tanks, &c. Now most of the works which are in operation use tanks which were originally designed for the lime process, which has been generally discarded because it makes a manure which is almost valueless. And again, the tanks are mostly all under cover, and the expense of their construction must have been great But at Stroud the settling tanks are open, and I was informed that there was no reason at all why they should not have been *earthen* reservoirs instead of masonry. I noticed much less smell from them than from the closed ones, and it is a fact that there is much less odour from sewage exposed to, than that hidden from, the light. A material saving might be effected in the drying of the residuum were the settlement to take place in earthen tanks, which might be left to dry without doing more than pump up the *moisture*, which should be allowed to sink into a well, or if the levels would admit, flow away by drain.

The drying, which takes an enormous time in England, would be soon effected by the fierce Indian sun.

It would be at all times desirable to have sewage works of whatever nature removed to as convenient a distance as possible from habitations, to meet all objections.

It will be observed that any system of deodorization and precipitation is extra to the sewers and drains, and does not affect the necessity for them. It proceeds to collect and prepare the solid part of sewage for the cultivator when it has arrived at the outfall. It does not reduce the outlay for drains, sewers, and water supply, like the dry system, which dispenses with the water for water-closets, and the drainage capacity for carrying it away again. It does not produce a manure so rich in the requisite amount of ammonia as that from the dry system, for a great part of that is lost in the oxidation that takes place in the long passage through the air that occurs before it can be fixed by some acid or earth.

It is somewhat difficult to realize that for any purposes of profit what remains from these processes is worth anything, more especially when we remember that the urine which contains so much fertilizing matter in solution is hardly affected by the treatment. It would appear that the solid residuum was not worth more than any ordinary decaying organic matter which will supply carbon to the roots of young plants, and perhaps worth about 1*l.* per ton. The prices, however, stated to be realized at the various works show that chemists do succeed in fixing a considerable amount of fertilizing ingredients. However this may be, it is undoubted that the dry processes, Moule's or Taylor's, must produce a better manure for least expenditure.

There are situations, however, where a system of deodorization and precipitation would be invaluable, and where any other would be impracticable, either from the want of land to irrigate, or the forced existence of an objectionable sewer outlet in a populous locality. I might mention the drain discharging into Back Bay, in the island of Bombay, as one of those positions where some deodorizing or precipitating process, or both, might be tried with effect.

Now as regards the different sorts of processes, the A.B.C. has an advantage that ought to be kept in view. It disposes of the blood from slaughter-houses; barrels of clay are sent to the houses and spread over the floors; this clay absorbs the blood at once, which through the manure eventually manufactured by its means thus finds its way back to the soil. Blood has been used for years as a manure in England, and its power is undoubted.

In any system of irrigation it will be probably necessary to have subsiding tanks for arresting the grosser parts of the sewage, and the more that is kept back from the feeding channels the cleaner will they be. Though I was informed at Worthing that they preferred to have the sewage when it was thick, which was not often the case, there certainly could not be a doubt that the objection to the foul state of feeders in general was not apparent there, and the crops did not appear to be any the less luxuriant.

It will be a question whether a great deal of the organic matter might not be kept back, and if required applied by hand in a dry state as a surface dressing. Thus the great objection to irrigation would be overcome, *i.e.*, the foul state of the feeders.

This seems to point to a combination of the precipitating and irrigating schemes.

Irrigation.

Irrigation in India is recognized to be a *sine quâ non.*

If it is to be desired with fresh water every available source of supply ought to be utilized. If we are to have towns sewered and supplied with bountiful stores of water, such as those from the lakes in existence or to be constructed for Bombay, Poona, and elsewhere, at a great expense, we shall only have done half the work if we throw it into the sea after washing our hands in it.

It is acknowledged that we have only to pour water on the soil to produce anything we desire, yet we would put up with want of forage for our horses, water in the milk, cattle devouring filth from sheer hunger, and spreading tape worms in consequence, want of good mutton for food, and general high prices of everything, while we will not spend a farthing on a remedy, but complacently throw our wealth into the sea. If irrigation is desirable in England, where there is no lack of moisture at all seasons of the year, and the country is prosperous, how much more is it required in India, where there is so much more scope for its application.

It seems certain that though it may appear at first sight unprofitable to pump sewage for irrigation in the neighbourhood of towns in India, the social improvement that would take place would more than repay the cost, even if could not be shown that a direct money value were received back again.

If the money saved in doctors' fees by reason of improved sanitation were added to the reduced cost of good milk and meat, &c. &c., a good account of saving might be shown. The rise in value of property in all healthy towns directly remunerates land and house owners.

The objections that have been raised to irrigation have been based, chiefly on the results of the experience of the last few years, during which it has been the practice to pour the sewage of a whole town over a few acres, thus producing what may be called a marshy state of ground and malarious state of atmosphere. But it has never been advanced that this is more than a step in the direction of irrigation, and all its advocates point to the general adoption of the system and extension of the area of ground as the ultimate aim to be attained.

At Cheltenham petitions have been received from cultivators owning a large amount of land that they may be supplied with sewage, and it is chiefly at their instigation that the local authorities have adopted the system.

It seems that after the water has done its service in the town it can be used to irrigate fields of grass, and that enormous crops may be grown, which are most profitably sold green, but may be made into hay. That in irrigating such land, with sewage the organic matter is almost entirely deposited on the land, and the water flows away containing only salts of lime, magnesia, &c., in solution. Thus we clearly see our way to utilizing the whole of the water of the sewage, for the grosser part can be used on rye grass or some other crop of that description suited to the climate, and

what flows away can be used again and again till it is used up, in irrigating crops that will not stand so much sewage, or the tailing water from a few acres may be passed off into an irrigational canal to swell the amount of its water without the least chance of polluting that water, but rather of increasing its fertilizing powers, provided there is no engineering difficulty in the levels to be overcome.

The majority of the towns in England are probably looking to irrigation as the solution of the difficulty of sewage disposal; but much remains to be done before it can be perfectly carried out, so that all the desiderata may be obtained. In the meanwhile it is impossible to look round and not see that a great advance has been made in purifying rivers and shores by the means already adopted, of whatever kind.

It would appear therefore certain, that in projecting a system of drainage by means of sewers for any town in India, they must be laid out with a view to the adoption of one or other method treated of, according to the advantages to be gained from the situation.

It would not be impossible even to apply a little knowledge gained from the system in operation at Manchester, which though it certainly does not appear to differ from that obtaining a hundred years ago, distinctly points out that a judicious application of ashes of the fuel used for cooking food acts as a deodorizer of the night-soil in the cesspits. The ashes of wood or cow dung would act in as efficient a manner, and if used to the "soil" as it is produced would render the soilmen's work less disgusting to themselves and the passers by in the streets.

A local law prohibiting the removal of "soil" not so protected, and inflicting a fine on persons having it on their premises more than a day, would effect the object probably.

In England the local Acts compel owners of houses to execute certain works essential to their well being—such as to supply themselves with water, with proper closets and drains, and similar Acts might it is presumed be passed for India.

In legislating, however, for local or other government it must not be forgotten that if the power is put entirely into the hands of landowners or householders, these are the persons who fearing they will be called on to spend money unprofitably directly any improvement is proposed, will be lukewarm probably on measures involving any such outlay. It is necessary to have persons of all shades of opinion, and it is a question whether some system of election similar to that in force for administering local Acts might not be beneficial under some government centralization in India.

LONDON:
Printed by George E. Eyre and William Spottiswoode,
Printers to the Queen's most Excellent Majesty.
For Her Majesty's Stationery Office.